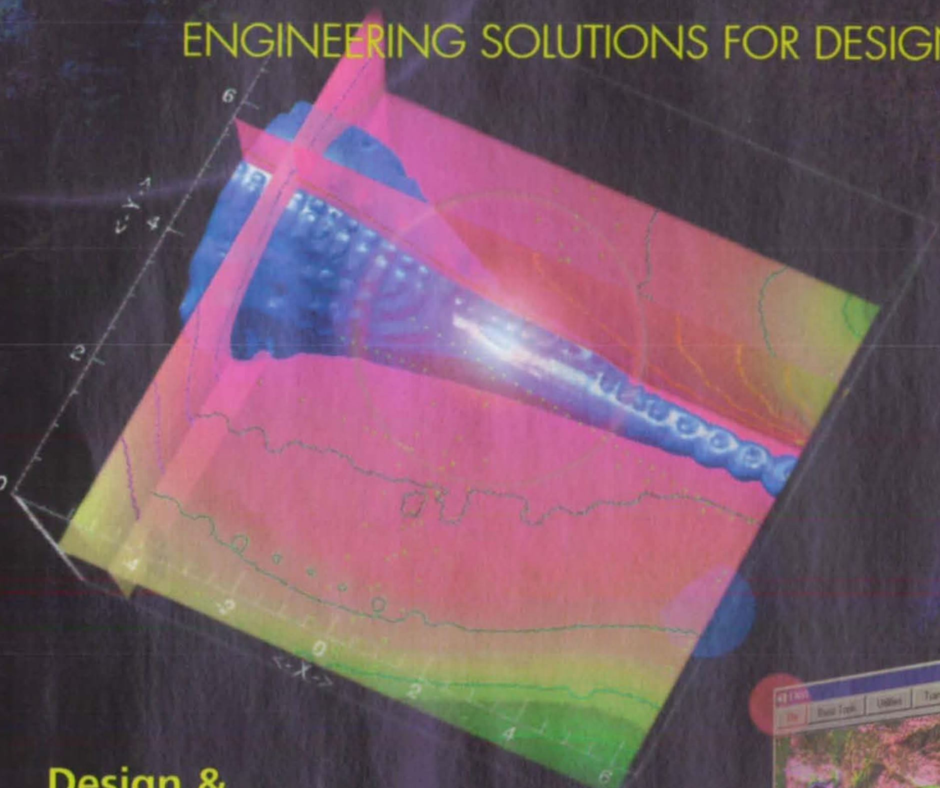
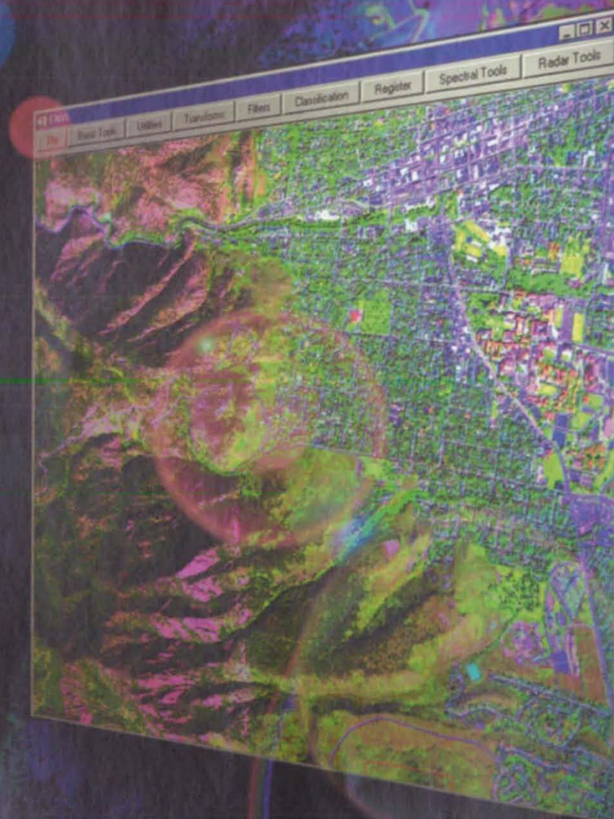
June 2000

NASA

TECH BRIEFS

ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING





Design & Analysis Software

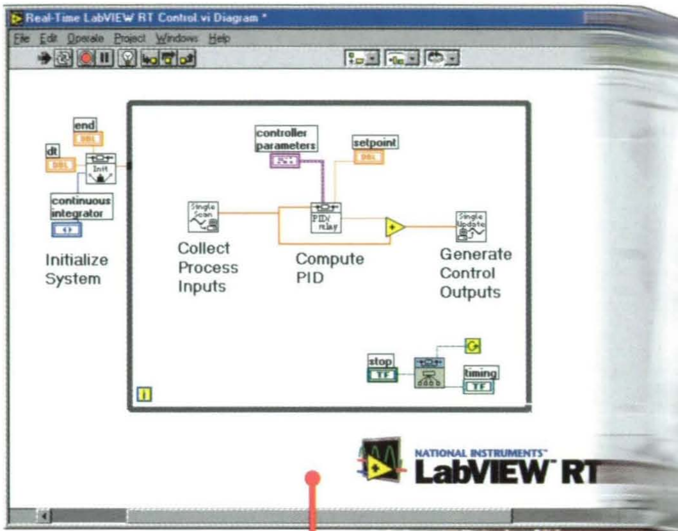
Computers & Peripherals

Electronics Tech Briefs

Motion Control Tech Briefs

www.nasatech.com

Real Time Real Easy



Create It

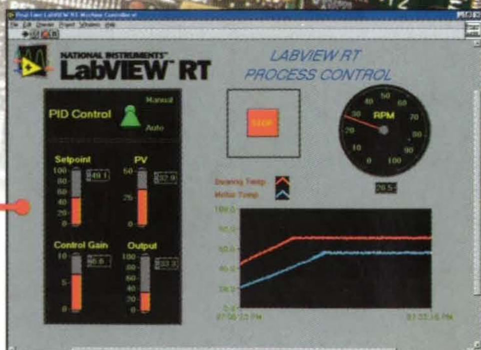
Develop your custom real-time control application with easy-to-use National Instruments LabVIEW™ RT running on a Windows-based PC.

Embed It

Download and run your application on a dedicated processor running a real-time operating system on the RT Series DAQ board for PCI or PXI™/CompactPCI.

Control It

Control your embedded system deterministically, without interruption, even if you must reboot.



NATIONAL INSTRUMENTS™

ni.com/info/lvrt **(800) 890-6229**

Tel: (512) 794-0100 • Fax: (512) 683-9300 • info@ni.com

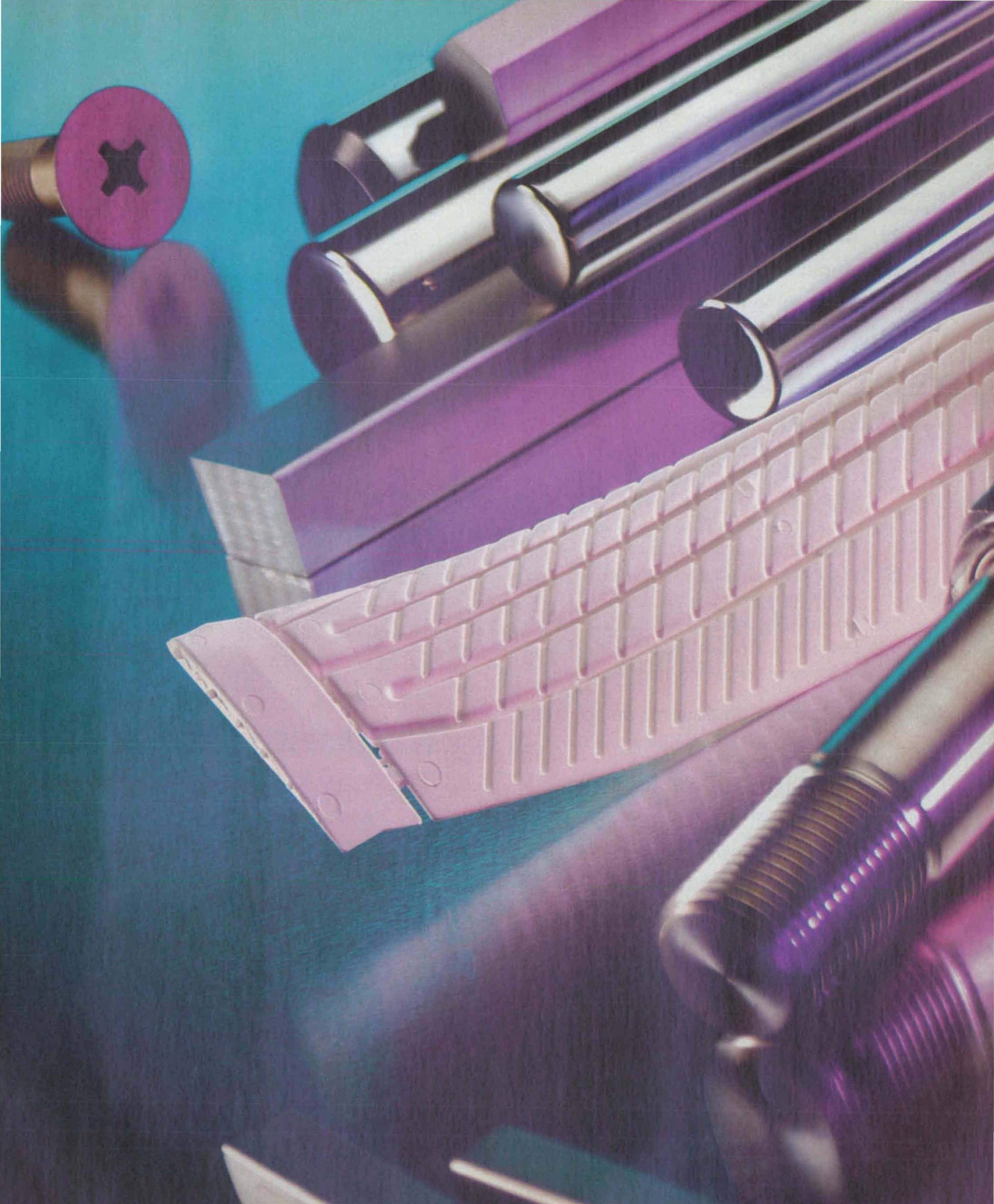
For More Information Circle No. 500

Call for your FREE Real-Time Product Selection Guide

BUY ONLINE!


The Pinnacle of Telemetry Recording
EVEREST™
Telemetry Recorder-Workstation
EVEREST
Large color display for real-time data viewing
Intuitive touch-screen interface simplifies setup and operation
Look-back while recording in real time
Up to 32 analog or digital input channels
Virtual Chart™ efficiently stores data while saving paper
Ethernet interface for command and control
High-resolution chart printing for clear, crisp traces
www.astro-med.com/ev16
For More Information Circle No. 518
Call, E-mail, Fax, or write to us today for all the details.
Astro-Med,® Inc.
TEST & MEASUREMENT SYSTEMS
Astro-Med is System Certified to ISO-9001
Astro-Med Industrial Park, West Warwick, Rhode Island 02893
Phone: (401) 828-4000 • Toll Free: 1-877-867-9783 • Fax: (401) 822-2430
In Canada Telephone 1-800-565-2216
E-mail: MTGroup@astro-med.com


Point...
Digi-Key .com
QUALITY ELECTRONIC COMPONENTS
SUPERIOR SERVICE
PARTS SEARCH
ONLINE ORDERING
CATALOG
ORDER STATUS
NEW PRODUCTS
INDUSTRY LINKS
ABOUT DIGI-KEY
CONTACT US
U.S. Web Site
Canadian Web Site
Click...
Done!
© 1999-2000 Digi-Key Corporation
The Website of Preference*
Value of Overall Content
Product Search Engine
Product Order Mechanism
Ease of Navigation
Access Speed
Electronic Buyers' News, Website Audit, June 28, 1999
Electronic Engineering Times, Website Audit, June 28, 1999
Cahners Research, How Engineers Worldwide Use the Internet, Nov. 9, 1999
www.
Digi-Key®
.com
1-800-DIGI-KEY
www.digikey.com



TECH BRIEFS
ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING
June 2000 • Vol. 24 No. 6

FEATURES

BRIEFS


68


65


20

DEPARTMENTS

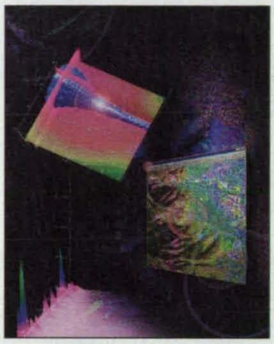
Contents *continued*

SPECIAL SUPPLEMENTS

PRODUCT OF THE MONTH

The MAX 200 digital document system from Xerox Engineering Systems, Stamford, CT, offers high-volume, wide-format digital printing, scanning, and copying.

ON THE COVER



These images of remote sensing data analysis were processed by ENVI® (Environment for Visualizing Images), NOeSYS™, and IDL® (Interactive Data Language) software from Research Systems, Boulder, CO. The company's IDL Wavelet Toolkit for image and signal processing analysis is featured in this month's Special Coverage on Design and Analysis Software, beginning on page 30.

(Images courtesy of Homestake Mining Company, University of Utah (upper left image), and the NASA Airborne Sensor Facility.)


WE'RE MAKING A BIG SPLASH ON OUR OWN.
KINGSTON'S STORAGE PRODUCTS DIVISION (SPD) The 12-year manufacturer of the original Data Express® and other RAID-ready storage enclosures is exploring new waters. Kingston®, the world's largest memory manufacturer, has formed a new sister company from its successful storage division. As of June 1, 2000 the new storage company will be known as StorCase™ Technology, Inc.
What will this mean to you? With plans to add more dedicated resources, StorCase will be able to further focus on new storage products and bring them to market sooner. Because StorCase will remain in the same facilities, you can count on this being a seamless transition, maintaining the same quality products, service and support.
StorCase Technology — making a big splash on its own. For more details, call a StorCase representative at (800) 337-8421 or visit us at www.storcase.com.
StorCase TECHNOLOGY
A Kingston Technology Company
ISO 9001 SGS
StorCase Technology, Inc. A Kingston Technology Company. 17600 Newhope Street, Fountain Valley, CA 92708, USA (714) 438-1850, Fax (714) 438-1847. © 2000 StorCase Technology, Inc. All rights reserved. All trademarks and registered trademarks are the property of their respective owners.

TECH BRIEFS

www.nasatech.com

BPA INTERNATIONAL

Published by .... **Associated Business Publications**
Publisher .... **Joseph T. Pramberger**
Chief Editor .... **Linda L. Bell**
Associate Publisher, *Photonics Tech Briefs* .... **Linda Silver**
Editor, Market Focus Editions .... **Robert Clark**
Internet Editor .... **Suzanne Bilyeu**
Production Manager .... **Margery Koen**
Assistant Production Manager .... **John Iwanciw**
Art Director .... **Lois Erlacher**
Production Artist .... **Christopher Coleman**
Circulation Manager .... **Hugh J. Dowling**

BRIEFS & SUPPORTING LITERATURE: Written and produced for NASA by **Advanced Testing Technologies, Inc.,** Hauppauge, NY 11788
Technical/Managing Editor .... **Ted Selinsky**
Sr. Technical Analyst .... **Dr. Larry Grunberger**
Art Manager .... **Eric Starstrom**
Staff Writers/Editors .... **Dr. Theron Cole, George Watson**
Graphics .... **Robert Simons**
Editorial & Production .... **Joan Schmiemann, Becky D. Bentley**

NASA:
NASA Tech Briefs are provided by the National Aeronautics and Space Administration, Technology Transfer Division, Washington, DC:
Administrator .... **Daniel S. Goldin**
Director, Commercial Technology .... **Dr. Robert Norwood**
Publications Director .... **Carl Ray**

ASSOCIATED BUSINESS PUBLICATIONS INTERNATIONAL
317 Madison Avenue, New York, NY 10017-5391
(212) 490-3999 FAX (212) 986-7864
Chairman/Chief Executive Officer .... **Bill Schnirring (bill@abpi.net)**
President/Chief Operating Officer .... **Domenic A. Mucchetti**
MIS Manager .... **Ted Morawski**
Webmaster .... **Albert Sunseri**
Credit/Collection .... **Felecia Lahey**
Human Resources Manager .... **Lourdes Del Valle**
Office Services Manager .... **Sylvia Ruiz**

NASA TECH BRIEFS **ADVERTISING ACCOUNT EXECUTIVES**
Headquarters .... (212) 490-3999
CT, MA, NH, ME, VT, RI, Eastern Canada .... **Ed Marecki**
at (401) 351-0274
NJ, NY, PA, DE .... **Jim Oot**
at (973) 316-9695
VA, MD, DC, NC, SC, GA, FL, AL, TN, MS, LA, AR, OK, TX .... **Bill Manning**
at (770) 971-0677
MN, ND, SD, WI, IL .... **Bob Casey**
at (847) 223-5225
IN, KY, MI, OH, MO, KS, IA, NE, Western PA & NY, Central Canada .... **Chris Casey**
at (847) 223-5225
CA, CO, AZ, NM, NV .... **Bill Hague**
at (800) 830-4351
WA, OR, ID, MT, WY, UT, Western Canada .... **Bill Madden**
at (503) 224-3799
S. Calif., Photonics Tech Briefs .... **Linda Silver**
at (310) 247-0317
International Sales .... **Rachel Di Santo**
at (0144) 01932-564999
Internet Advertising .... **Luke Schnirring**
at (212) 490-3999
TechDeck Postcard Advertising .... **Erving Dockery**
at (212) 490-3999
Trade Show Sales .... **Carolyn Lighty**
at (727) 796-5550, ext. 135

For a complete list of staff e-mail addresses, visit www.nasatech.com

NASA Commercial Technology Team

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. Call (609) 667-7737 for the FLC coordinator in your area.

NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Carolina Blake
(650) 604-1754
cblake@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3802
lee.duke@dfrc.nasa.gov

Goddard Space Flight Center
Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Remote Sensing; Command.
George Alcorn
(301) 286-5810
galcorn@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
Merle McKenzie
(818) 354-2577
merle.mckenzie@jpl.nasa.gov

Johnson Space Center
Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.
Hank Davis
(281) 483-0474
henry.l.davis1@jsc.nasa.gov

Kennedy Space Center
Selected technological strengths: Command, Control, and Monitoring Systems; Range Systems, Fluids and Fluid Systems; Materials Evaluation and Process Engineering.
Gale Allen
(407) 867-6226
gale.allen-1@ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Sam Morello
(757) 864-6005
s.a.morello@larc.nasa.gov

John H. Glenn Research Center at Lewis Field
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Larry Viterna
(216) 433-3484
cto@grc.nasa.gov

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Sally Little
(256) 544-4266
sally.little@msfc.nasa.gov

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
Kirk Sharp
(228) 688-1929
kirk.sharp@ssc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the Regional Technology Transfer Center nearest you, call (800) 472-6785.

Joseph Allen
National Technology Transfer Center
(800) 678-6882

Ken Dozier
Far-West Technology Transfer Center
University of Southern California
(213) 743-2353

Dr. William Gasko
Center for Technology Commercialization
Massachusetts Technology Park
(508) 870-0042

J. Ronald Thornton
Southern Technology Applications Center
University of Florida
(352) 294-7822

Gary Sera
Mid-Continent Technology Transfer Center
Texas A&M University
(409) 845-8762

Lani S. Hummel
Mid-Atlantic Technology Applications Center
University of Pittsburgh
(412) 383-2500

Chris Coburn
Great Lakes Industrial Technology Transfer Center
Battelle Memorial Institute
(440) 734-0094

NASA ON-LINE: Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at **http://nctn.hq.nasa.gov** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

Carl Ray
Small Business Innovation Research Program (SBIR) & Small Business Technology Transfer Program (STTR)
(202) 358-4652
cray@mail.hq.nasa.gov

Dr. Robert Norwood
Office of Commercial Technology (Code RW)
(202) 358-2320
rnorwood@mail.hq.nasa.gov

John Mankins
Office of Space Flight (Code MP)
(202) 358-4659
jmankins@mail.hq.nasa.gov

Terry Hertz
Office of Aero-Space Technology (Code RS)
(202) 358-4636
thertz@mail.hq.nasa.gov

Glen Mucklow
Office of Space Sciences (Code SM)
(202) 358-2235
gmucklow@mail.hq.nasa.gov

Roger Crouch
Office of Microgravity Science Applications (Code U)
(202) 358-0689
rcrouch@hq.nasa.gov

Granville Paules
Office of Mission to Planet Earth (Code Y)
(202) 358-0706
gpaules@mtpe.hq.nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
(216) 586-3888

B. Greg Hinkebein
Mississippi Enterprise for Technology
Stennis Space Center, MS
(800) 746-4699

Joe Boeddeker
Ames Technology Commercialization Center
San Jose, CA
(408) 557-6700

Marty Kaszubowski
Hampton Roads Technology Incubator (Langley Research Center)
Hampton, VA
(757) 865-2140

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622.

Reader Forum

Reader Forum is dedicated to the thoughts, concerns, questions, and comments of our readers. If you have a comment, a question regarding a technical problem, or an answer to a previously published question, post your letter to Reader Forum on-line at **www.nasatech.com,** or send to: Editor, *NASA Tech Briefs*, 317 Madison Ave., New York, NY 10017; Fax: 212-986-7864. Please include your name, company (if applicable), address, and e-mail address or phone number.

The NASA Patents column on page 18 of the April issue features a solid state carbon monoxide sensor. Does anyone know of a source for such a sensor?

Tony Caristi
info@amperite.com

*(**Editor's Note:** Tony, I suggest you contact the Commercial Technology Office at Langley Research Center in Hampton, VA, where the work was performed. Call 757-864-6005, or e-mail Sam Morello at s.a.morello@larc.nasa.gov.)*

Technologies Wanted

As a regular part of Reader Forum, we'll be featuring abstracts of Demand Pull Technology Transfer projects. These projects identify technology needs within an industry segment — such as Assistive Technology — and find technology solutions to meet those needs. The Rehabilitation Engineering Research Center on Technology Transfer has developed the Wheeled Mobility Project to identify market needs like those described below that represent significant business opportunities. For more details on the project — or to submit technology solutions — visit the project web site at www.rti.org/technology/wheelchairs.

Battery Monitoring Technologies

Power wheelchair users need accurate knowledge of a battery's state of charge. An ideal battery monitor must be compatible with wet or gel electrolyte, lead-acid battery technology, and provide an accurate, instantaneous measure of residual power — similar to a fuel gauge. It should track battery degradation rate; translate battery power into a percentage of capacity, time, or distance remaining; and provide replacement alerts. The monitor must compile the charge/discharge/recharge history to develop an energy consumption profile for the user while not interfering with wheelchair controller functions.

Transmission Technologies

Power wheelchairs use direct and indirect transfer drivetrains composed of gears, belts, chains, and other mechanical elements that reduce motor speed while proportionally increasing motor torque.

An ideal transmission should deliver high torque under high loads, and provide safe, reliable steering and acceleration through coordinated transmission gear shifting for both wheels. A short-term solution would be a manual two-speed transmission; an intermediate solution would be an automatic two-speed transmission. Longer term, an automatic transmission with a continuously variable gear ratio would increase performance and complexity.

NASA Patents

Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. The agency has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Soft-Sided Air Displacement Volumometer

(U.S. Patent No. 5,948,977)

Inventor: Steven F. Siconolfi, Johnson Space Center

The standard technique for measuring a patient's total body volume has been underwater weighing, also called hydrostatic weighing, which measures the difference between a subject's weight out of water and that submersed in water. The subject's body volume equals the volume of displaced water. Although generally accurate, this technique requires complete submersion of the person and maximal expulsion of air from his lungs. Such submersion may be impossible because of the patient's condition. This team proposes a soft-sided bag equipped with an air injector, a pressure transducer, and a recording device. The subject is placed in the bag, and it is sealed and pressurized using the air injector to an initial pressure level. One end of the bag is compressed by rolling it up, and the pressure inside is determined at that position. The bag is further compressed to a second position and the pressure again determined. As the bag is compressed, the volume inside reduces, and the pressure, which increases, is indicative of the total volume in the bag.

Detector for Particle Surface Contamination

(U.S. Patent No. 5,870,186)

Inventors: Paul A. Mogan, Christian J. Schwindt, and Carl B. Mattson, Kennedy Space Center

A need exists for a particle surface contamination detector that can automatically provide analysis of fallout particle numbers and sizes as well as real-time measurements of particle fallout rates. The present system employs a flat, smooth, transparent particle collection surface in a housing. An aperture is formed in the housing top over a portion of the transparent collection surface to allow particle fallout to collect on it. Disposed beneath the surface in the housing is an optical detector, such as a camera, which images the particles. In a preferred embodiment of the invention, the particle collection surface is the top of a rotatable circular disk, such as a transparent unprinted CD, for example, which is rotated by a first drive motor at a slow speed (e.g., 1 rpm), so that the particle fallout is collected over a larger surface area than that defined by the aperture. A second motor drives a cam element that moves the subassembly linearly back and forth in increments over the camera to facilitate random sampling of different portions of the disk's collection surface.

Evaporative Cooling Membrane Device

(U.S. Patent No. 5,946,931)

Inventors: Curtis Lomax and John Moskito, Ames Research Center

A heat sink device particularly suitable for operations in high-altitude environments is a sublimator/evaporator system in which liquid flows around the outside of tubes, while the tube interior is vented directly to a vacuum. A portion of the liquid experiences a liquid-to-vapor change, releasing latent heat therefrom, and leaving the remaining fluid cooled to serve as a medium for heat-sinking purposes. But the flow rate of this system is limited by the internal orifice size of each tube. The present invention is an evaporative cooling device that does not suffer from tubular flow-rate limitations, but rather has a plate configuration that allows for increased flow rates and provides convenient control of evaporation rates of the device by adjusting the rate of flow of the fluid that yields the cooling effect. The device comprises a housing with four enclosed sidewalls, an enclosed bottom, and an exposed face covered with at least one sheet of a hydrophobic porous material. One of the sidewalls has an entrance opening and the one opposite it an exit opening. The porous membrane material has pores that resist the liquid state from passing through, but allows passage of the fluid in its vapor state, thereby causing evaporation of the fluid that cools the remaining fluid.

For more information on the inventions described here, contact the appropriate NASA Field Center's Commercial Technology Office. See page 12 for a list of office contacts.

UpFront

PRODUCT OF THE MONTH

Xerox Engineering Systems, Stamford, CT, has introduced the MAX 200 wide-format digital document system that operates at 7.9" per second, delivering more than 1,020 D-size prints and 540 E-size prints per hour. It also features a highlight red option that allows users to communicate critical changes and hard-to-see details with red ink. Other features include dual 400-DPI LEDs for image quality, 256 levels of gray, and the ability to print in red, black, or both. The system provides six media sources, including four rolls, 1 x 1000 cut-sheet tray, and manual bypass. A modular, multi-tasking network controller for digital network printing is available with an optional scan-to-file capability that enables the system to print and scan-to-file concurrently. A full-featured job control server also is available.

For More Information Circle No. 747

A Gateway to Technology

Do you want to know what NASA's doing to develop emerging technologies and how it's using them to address today's challenges? Well, in addition to reading *NASA Tech Briefs*, you can find information at a new Web site — the NASA Technology Portal. The new Internet gateway offers a look into the core of NASA's technology development and tech transfer programs.

Users can capitalize on technologies developed by NASA, explore opportunities to develop new technologies with NASA, or learn what unsolved aerospace challenges NASA faces and propose technologies to meet them. Visit the new site at http://nasatechnology.nasa.gov.

NASA Continues Cancer Fight

NASA Administrator Daniel S. Goldin and National Cancer Institute (NCI) Director Dr. Richard Klausner signed a Memorandum of Understanding to jointly develop new biomedical technologies that can detect, diagnose, and treat disease on Earth and in space. NASA is seeking to develop a new form of patient care "microscopic explorers" that would travel through the body looking for disease. The NCI is attempting to define cancer for the first time based on the unique molecular characteristics of tumors.

Miniaturized diagnostic and treatment technologies that continuously monitor wellness and treat disease could be used by astronauts on the International Space Station, where there is not room for large CAT scan or MRI equipment. The "nano-explorers" might enter the body as a pill, a nasal spray, or a skin patch, and continually evaluate molecular indicators of health by communicating with on-board computers.

The NCI envisions that these space technologies also will change healthcare as we know it on Earth, including the early detection and treatment of cancer. For more information, and to view the text of Administrator Goldin's remarks, visit www.nasa.gov/newsinfo.

Your neighbor may have it in his new sports car. It may be in your desktop PC. NASA uses it to lubricate space-going mechanisms such as bearings, momentum wheels, boom/array deployment mechanisms, and payload gimbals. It's also used to lubricate hard drives and magnetic disks.

This revolutionary product is Pennzane® X2000 synthesized hydrocarbon fluid developed by Pennzoil-Quaker State, Houston, TX. Last year, the company introduced Pennzoil® Synthetic, a new line of full synthetic motor oils formulated with Pennzane. The fluid is the result of Pennzoil's decade-long investment in the research, development, and testing of synthetic lubricants that meet the extreme conditions found in space.

The Road to Outer Space

In the mid-1980s, scientists and engineers at Pennzoil's Woodlands Technology Center began basic research on a sophisticated family of synthetic lubricants. "I was interested in making new synthetic fluids, and the manufacturing division needed to upgrade a byproduct stream," explained Dr. Clifford Venier, one of the developers of Pennzane. "The stream contained significant quantities of cyclopentadiene, a very unusual chemical. It's a hydrocarbon, yet it's a weak acid, so it easily undergoes condensation reactions to make bigger molecules."

Pennzane is the result of Pennzoil's decade-long investment in the research, development, and testing of synthetic lubricants that meet the extreme conditions found in space.

Scientists take fairly small, ordinary molecules and string them together to make bigger molecules, according to Venier. "That's how the main commercial synthetic fluids — the polyalphaolefins — are made. So it looked like a good place to start. We got started looking at some reactions that put other hydrocarbon groups on the cyclopentadiene," said Venier. "It's a very small molecule, with only five carbons, and quite volatile. We put up to six groups on it to make it heavier and less volatile. We made a whole series of these, called multiply-alkylated cyclopentanes, or MACs, that can be used for any kind of lubrication application." One of those MACs became X2000.

Dr. Clifford Venier (right) and Dr. Edward Casserly, co-inventors of Pennzane X2000 synthesized hydrocarbon fluid.

Pennzane was conceived, developed, and produced in only two years. But even after small batches were produced, the developers — Venier and fellow scientist Dr. Edward Casserly — weren't sure of its commercial potential. That is, until Pennzoil participated in a conference in 1985 in which members of the aerospace community identified a need for a lubricant that would be stable under extreme temperatures and provide excellent lubricating qualities.

The aerospace experts needed a lubricant that was a fluid at a very low temperature, yet would not evaporate at a high temperature. "In the catalogue of things we'd done," said Venier, "there was this one that looked like it had those kinds of properties." Those properties included the ability to lubricate parts in vacuum conditions in the cold of outer space for up to 25 years.

Once the idea for Pennzane was developed, Venier and Casserly began creating small quantities in the lab. "When developing a new product, we have to go in and run the reactions and purify it," Venier explained. "Typically, to screen a new material, we would make only a few hundred grams. From that, we could get the properties and determine if it will be useful."

As far as Pennzane was concerned, Pennzoil could "make it once and have enough for a long time," said Venier. "One of the advantages Pennzane had for initial commercialization is that it's a very high value product. The material sells for about $1,000 per kilogram or $450 per pound. Part of the reason for that is the small volume required. You don't have to build a plant to process it. You can start out small."

Pennzane X2000 may have started out small, but in 1986, it was presented to NASA contractors as a developmental fluid for application in space. The initial review was favorable, and Pennzane was on its way toward commercialization.

Its original commercial use was in 1987, when Pennzane was shipped to

NASA contractor TRW (Redondo Beach, CA), which began using it in a variety of applications for equipment deployed in outer space. It was used in the Clouds and the Earth's Radiant Energy System (CERES) instrument, the most precisely calibrated radiometer ever to fly in space. CERES measures emitted and reflected energy from the surface of the Earth and the atmosphere. CERES provides scientists with the most accurate eye ever for measuring clouds and their impact on Earth's radiant energy system. NASA has assigned CERES the highest priority in its Earth Observing System (EOS) program.

Today, Pennzane is used to lubricate mechanisms in the Rossi X-ray Timing Explorer (RXTE) satellite; the Geostationary Operational Environmental Satellites (GOES), which provide 60 percent of the Earth's weather reports and track distress signals to locate stranded sailors; and the Tropical Rainfall Measuring Mission (TRMM), which performed climate research such as improving precipitation measurement techniques and developing representative rainfall climatologies.

It Really *Is* Rocket Science

The resulting commercial motor oil, Pennzoil Synthetic with Pennzane, provides extra engine protection against deposits and wear resulting from severe driving conditions. It provides this protection when engines need it most, such as at temperature extremes. While not subjected to the severe temperature fluctuations of outer space, the oil protects cars at very low and very high operating temperatures.

The oil is designed to protect against both oxidative and thermal breakdown, and the accelerated oil consumption associated with severe service conditions such as short-trip driving with frequent engine starts and stops.

Pennzane X2000 fluid can be used in any application requiring a low volatility hydrocarbon. It's designed for lubrication in vacuum environments, as well as applications requiring no condensables, such as computers and precision instruments. The utility of Pennzane X2000 can be extended by adding typical hydrocarbon additives, such as extreme pressure agents, antiwear agents, and antioxidants.

For more information on Pennzane X2000, visit the Pennzoil web site at www.pennzoil.com.

Douglas B. Leviton, Optical Physicist, Goddard Space Flight Center

Douglas B. Leviton is an optical physicist at NASA's Goddard Space Flight Center in Greenbelt, MD. He has worked on a variety of optical technologies for ultraviolet through infrared wavelengths for NASA science missions including the Hubble Space Telescope (HST). His absolute optical encoder technology was honored as NASA's Government Invention of the Year for 1999. (See page 22 of the May issue of *NASA Tech Briefs* for more information on NASA's awards.)

***NASA Tech Briefs:* What is an absolute optical encoder?**

Douglas B. Leviton: Optical encoders measure mechanical position and report it to a computer as a number. For example, a rotary encoder mounted on a large telescope's support bearings tells you the telescope's pointing angle. In a milling machine or a lathe, linear encoders mounted on the machine's slides tell you the position of the cutting tool with respect to the part being machined. Some encoders are incremental, which means that if you turn the power off and turn it back on, the encoder gets lost because its reference is lost. With an absolute encoder, you can turn power off and back on, and when the encoder wakes up, it still knows exactly where it is. This is especially advantageous in space mechanisms where conserving power is important.

NTB: What advantages does your invention provide?

Leviton: Conventional absolute encoders sense a bit pattern on glass that is unique at each position. The limitation on resolution is, "How small can you make the finest little bit?" Instead of reading out individual bits, my absolute encoder takes digital pictures of a different kind of pattern and interprets them through software to get position with much higher resolution. The pattern resembles coarsely spaced pickets in a fence. Each picket has a little bar code that uniquely identifies it. The camera sees two or three pickets at a time. Since only one position is being measured, each one of those pickets gives the same answer. This means that a pretty vast area on the scale can be damaged and the encoder still works fine.

NTB: What was NASA's first application for the new encoder?

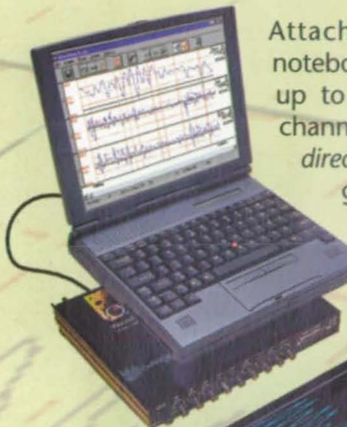
Leviton: The very first application was in 1998 for a system we built to calibrate flight prisms for the HST Advanced Camera for Surveys (ACS). That system was essentially a vacuum UV version of the classical, prism refractometer for measuring refractive index of transmissive optical materials. We needed a cheap rotary encoder in vacuum with sub-arcsecond accuracy in a hurry, so we engineered a special version of the new encoder in just a few weeks for less than $1,000. Meanwhile, we ended up enhancing the world's database of far UV optical material properties with data of unprecedented accuracy and spectral coverage. The materials we measured are crucial to other NASA UV science missions and are being used increasingly in optical designs of wafer steppers for advanced semiconductor production.

NTB: What are some potential commercial applications for your invention?

Leviton: Any mechanism requiring absolute encoders more sensitive and compact than existing encoders can take advantage of this new technology. One example would be linear positioning platforms for microlithography steppers. Other potential applications include inspection equipment, robotics, machine vision, coordinate-measuring equipment, aviation, surveying, profilometers, and disk-drive manufacture.

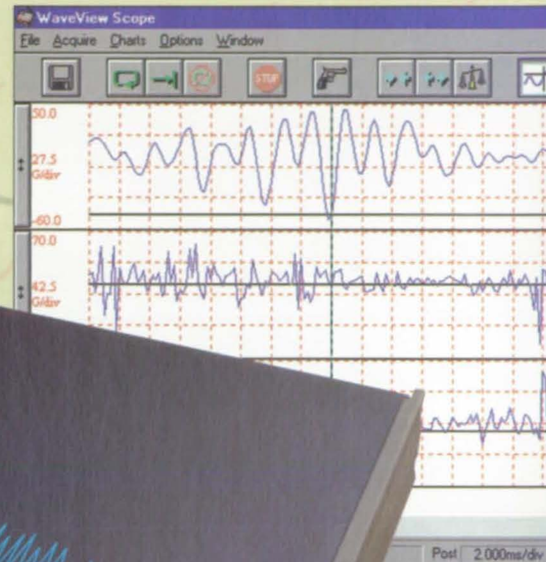
A full transcript of this interview appears online at www.nasatech.com. Mr. Leviton can be reached at doug.leviton@gsfc.nasa.gov.

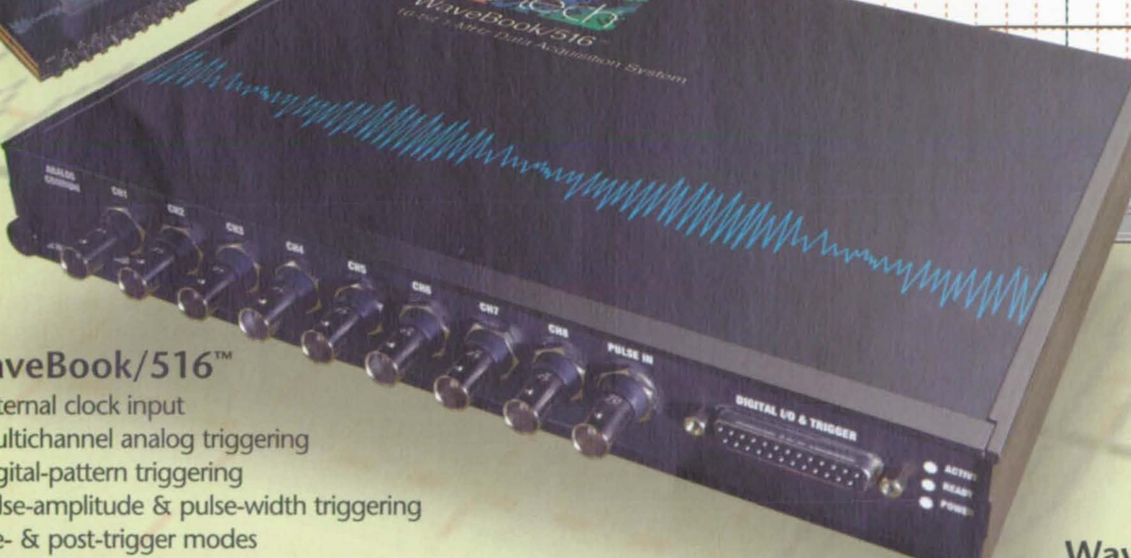
Portable 16-Bit, 1-MHz Measurements



Attach the new **WaveBook/516™** to your notebook PC for portable, 16-bit measurements up to 1 Msamples/s. Start with eight built-in channels, and easily expand up to 72, including *direct-connect* signal conditioning for strain gages, ICP®-style accelerometers, *and more.*

WaveView™

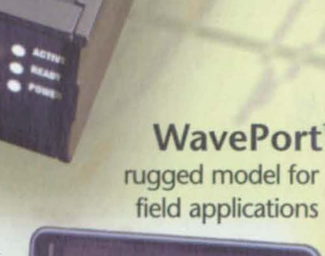




WaveBook/516™

- External clock input
- Multichannel analog triggering
- Digital-pattern triggering
- Pulse-amplitude & pulse-width triggering
- Pre- & post-trigger modes
- In-vehicle bus option

WavePort™
rugged model for field applications



Included *Out-of-the-Box™* **WaveView™** software converts your PC and the WaveBook/516 into a compact, multichannel waveform analyzer, streaming data to your PC's hard drive in real time. Windows® 95/98/2000/NT drivers, as well as LabVIEW® and DASYLab® support, are also included.

IOtech has been the undisputed leader in portable, notebook PC-based data acquisition for nearly a decade.

SHOP ON LINE

Visit our Web site at **www.wavebook.com** and see why the WaveBook/516 is first in its class. For a demo or 30-day evaluation, contact our sales department at **1.888.805.3020** or **sales@iotech.com.**

www.wavebook.com

WEB QUICK FIND #405*

For a complete listing of IOtech worldwide sales offices, see www.iotech.com/sales.html

Australia 61 3 9569 1366; **Austria** 43 676 708 3189; **Belgium** 31 162 472 461; **Brazil** 55 11 853 2733; **Canada** (905) 890 2010; **China** 86 10 6232 9880; **Denmark** 45 43 71 64 44; **Central Europe** 431 54 51588; **Finland** 358 9.4761600; **France** 331 3489 7878; **Germany** *Synotech* 49 2462-99-19-0; *Spectra* 49 7119-02-97-0; **Greece** 30 33 17 6501; **Hong Kong** 852-2833-9987; **India** 91-80-655-4993; **Indonesia** 65-482-5600; **Israel** 972-3-649-8538; **Italy** 39 02 392 66561; **Japan** 81 3-3279 0771; **Korea** 82 2 538-4001; **Malaysia** 603-7783-6920; **Netherlands** 31 162 472 461; **New Zealand** 64 9309 2464; **Norway** 47-22-76-40-00; **Portugal** 349-1-570-2737; **Singapore** 65-482-5600; **South Africa** 27-11-254-8420; **Spain** 349-1-570-2737; **Sweden** 46-13-357030; **Switzerland** 411-802-2880; **Taiwan** 886 2 2797 3357; **Thailand** 65 482-5600; **United Kingdom** 44 1296 397676

IOtech

1.888.805.3020

IOtech Inc.
25971 Cannon Rd
Cleveland OH 44146
Fax 1.440.439.4093
sales@iotech.com

CIRCLE 401

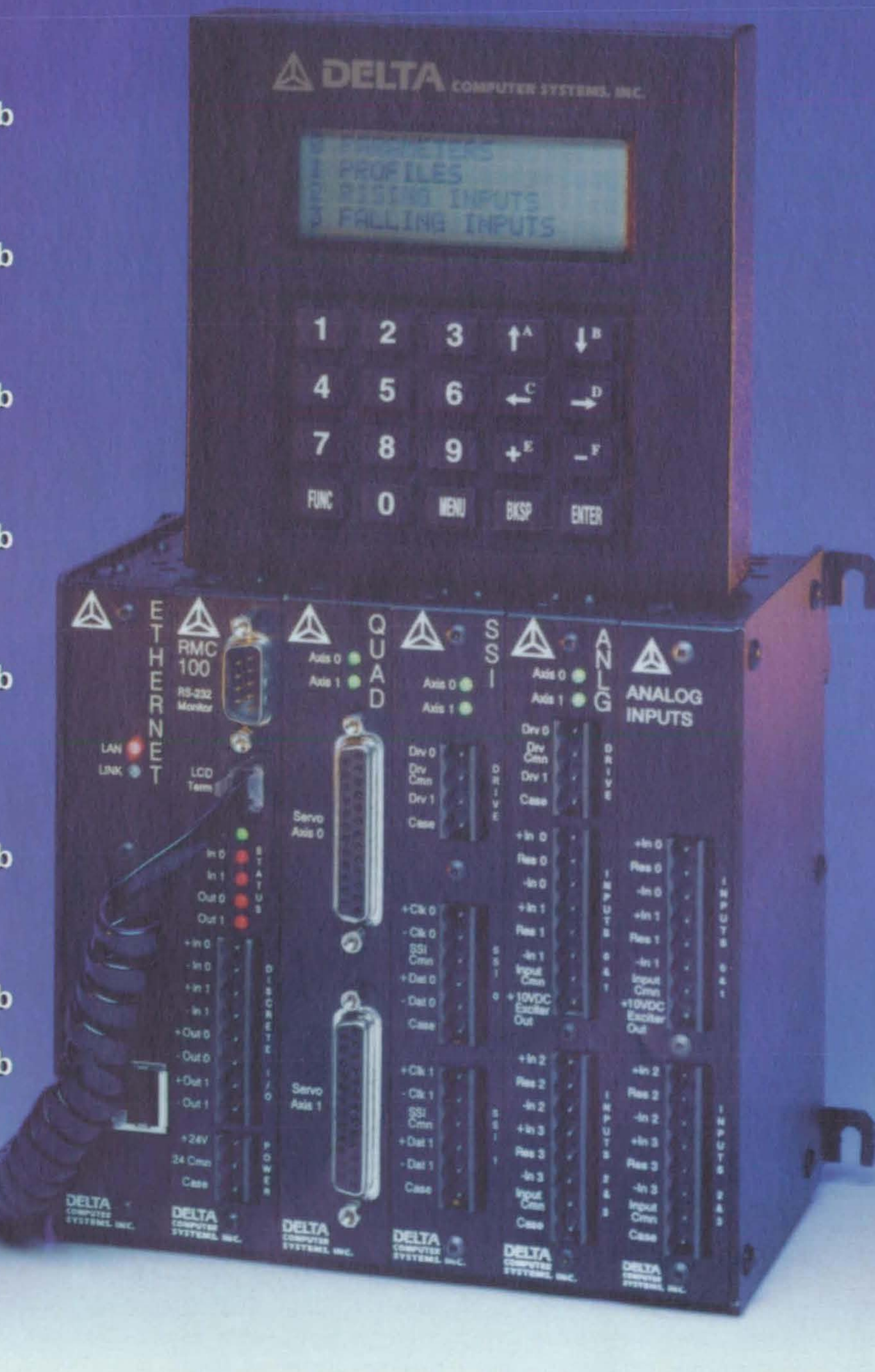
ISO 9001

CE

* For up to date information on products, and to order online, visit the IOtech Web site and enter the **QUICK FIND** number.

June 2000

Motion Control Tech Briefs



Cover photo courtesy of Delta Computer Systems Inc. See "New Products."

CMM Makes Its Move

Chassis monitoring and management (CMM) can reduce motion control system hardware and integration costs.

Chassis monitoring and management (CMM) functions are critical in many motion control applications, particularly those involving high value-added production, where reliability and personnel safety are paramount. To effectively support reliability and safety, it is important to know the status of the motion control devices, but also the total environment in which they operate. CMM provides this feedback by continuously logging data on variables such as temperature, humidity, cooling, power performance, and other diagnostic information.

Today's motion control systems consist of three primary layers: supervisory control, data acquisition, and sensors and final actuators. Each of these may contain several complex subsystems that must interact not only within the layer, but also with other layers in the larger system. Although current technology provides process control and feedback of these subsystems, the ability to monitor and diagnose CMM variables between these subsystems through a central integrating host is lacking.

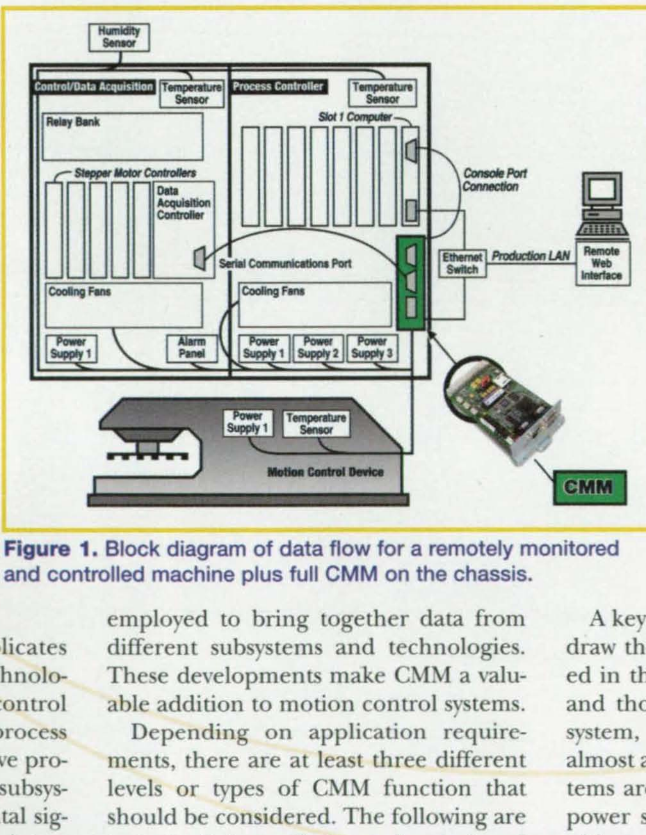


Figure 1. Block diagram of data flow for a remotely monitored and controlled machine plus full CMM on the chassis.

Another problem that complicates monitoring is the diversity of technologies used within many motion control systems designed for factory and process floor applications. Often these have progressed from strictly PLC-based subsystems to also incorporate PCI, digital signal processing, and other proprietary monitoring and control elements. Additionally, subsystems. sensors, and monitored variables are dispersed throughout the larger system, making them inherently difficult to monitor and control through a single source.

In VME and PCI card-based systems, CMM functions are often integrated within the electronic packaging. They let the user know, for example, when there are problems with power supplies and cooling fans, and often allow remote management of these system functions. More recently, CMM functions in these systems have been expanded to include variables outside the electronics packaging, such as those associated with the system environment and electromechanical assemblies. Also, modern networking technology is being employed to bring together data from different subsystems and technologies. These developments make CMM a valuable addition to motion control systems.

Depending on application requirements, there are at least three different levels or types of CMM function that should be considered. The following are typical of those that can be designed into your motion control system:

- Level 1: Simple monitoring only (typically voltages, temperatures, and cooling fan operation, with local LED indication of failure);
- Level 2: Microcontroller-based monitoring (voltage, fans, temperature and power supply status monitoring with remote access to status; also remote management features such as power on/off and reset);
- Level 3: Microprocessor-based web-enabled real-time operating systems (adds advanced-platform independent features, such as remote access via web browser to configure the system, access log files, and collect general diagnostic data).

Since CMM functions are not a central part of the motion control system, they are frequently treated as an afterthought. However, thinking about them early in the design cycle allows the most cost-effective make/buy decisions involving criteria such as hardware purchases, programming, system integration, space efficiency, and future expansions or modifications. Before specifying and launching a CMM design, it is best to check features available from the system packaging supplier. You may get more of these functions at a lower cost than taking the do-it-yourself route. This can put more profit on the bottom line and also get your product to market much faster.

Design Cost Tradeoffs

A key design issue in CMM is where to draw the line between functions included in the motion control system boards and those supplied with the packaging system, or as a separate module. It is almost a given that today's packaging systems are supplied with modular plug-in power supplies and cooling fans, often with a n+1 redundancy. Also typical in these designs is local monitoring of all power-supply voltages, chassis temperature, and fan operation. The nature of a motion control system, however, suggests the need for remote monitoring and control of these functions, plus additional data collection for diagnosis.

For example, consider manufacturing equipment that is remotely monitored and controlled through electronics installed in a local system chassis. A

Create

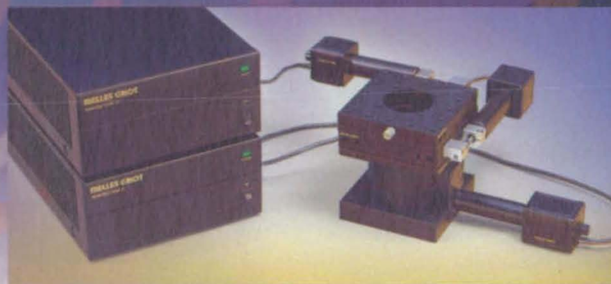
Transform

Detect

A Revolution in Resolution

The ultimate in motorized nanometric positioning . . .

Nanomotion II™



Nanomotion II™ Controller

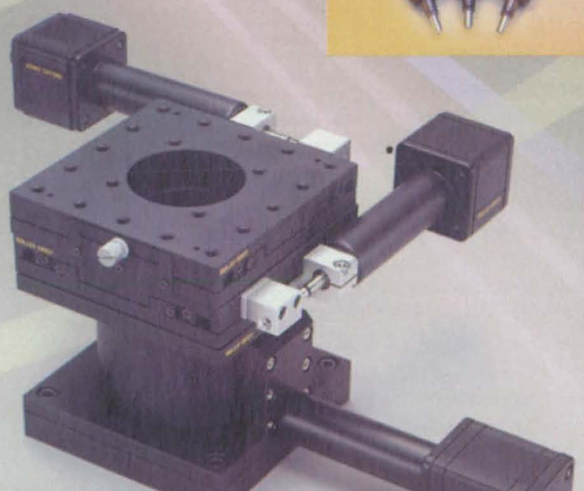
- Expands to control up to 16 actuators
- IEEE-488, RS-232C, or IBM-ISA interface
- Joystick option for computer-free control
- Easy to configure and upgrade

Nanomover™ Actuator

- 25-mm travel with 10-nm resolution
- Up to 20-kg load capacity
- Flat or spherical contact tip
- Includes calibration graph
- Robust

Nanomotion™ Software

- Works with MS DOS or Windows
- LabVIEW™ drivers
- 16-bit DLL and C libraries
- Sample programs



Find out more:
1-800-835-2626
www.mellesgriot.com/mg167.htm

the practical application of light

MELLES GRIOT

Photonics Components
16542 Millikan Avenue, Irvine, CA 92606 • 1-800-835-2626 • (949) 261-5600 • FAX (949) 261-7790 • E-mail: sales@irvine.mellesgriot.com

Asia (03) 3407-3614 **Europe** (0316) 333041

www.mellesgriot.com

A member of Barlow Scientific Group Ltd.

For More Information Circle No. 600

block diagram for such a system is shown in Figure 1. However, automatic equipment, such as plastic molding machines and electromechanical test fixtures, require not only motion control but also diagnostics that provide early warning of impending failures, and data that directs technicians to the failure point when one occurs.

Historically, these troubleshooting functions have been accomplished by technicians manually collecting data from a machine's diagnostic port. However, the packaging vendor may be able to suggest CMM functions that eliminate or reduce manual methods of local diagnostics. For example, a high-performance inspection system developer initially purchased a barebones VME64 chassis and then designed in Level 2 monitoring of the type described earlier.

Figure 2. Illustration of typical chassis with local monitoring shown.

When Tracewell Systems, an electronic packaging system manufacturer, was approached about supplying such functions on the system chassis, their designer pointed out the benefits of Level 3 CMM. For a relatively small cost premium, they were able to provide remote bidirectional monitoring and control from external PCs and workstations interconnected on a LAN/WAN network by using web browser technology.

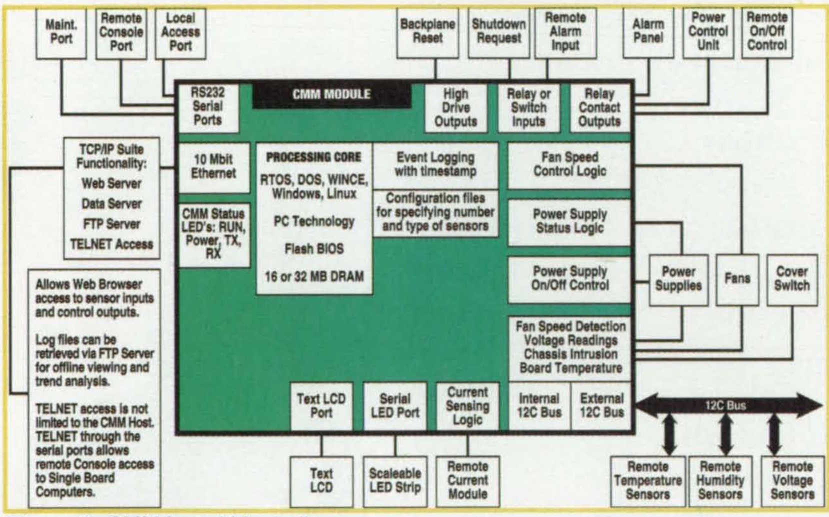


Figure 3. CMM board block diagram.

Such a system can be interfaced to either PLC- or PC-controlled equipment and facilitates integration of other technologies. It also provides near-real-time machine diagnostics. Level 3 CMM possibilities include:

• Monitoring functions (all power-supply voltages, cooling-fan air flow or RPMs, multiple chassis temperatures, humidity, high-water alarm, chassis intrusion);

• Management functions (power-cycle control of remote equipment, download CMM log files, console port access of remote equipment, upload configuration changes such as operating parameters, alarm thresholds, etc., change network/IP address of the chassis);

• Record and or route diagnostic data from machines being controlled.

Off-loading CMM functions to the system chassis lets the developer concentrate on core tasks associated with motion control. With only local monitoring of chassis variables, perhaps this is not a big deal. However, remote CMM via web browsers adds considerable complexity. Table 1 lists development tasks associated with Level 3 CMM, which illustrates this point.

The design of a typical Tracewell Level 3 CMM system can be implemented as an integral part of the electronic system packaging, or supplied as a separate module to be installed elsewhere in the OEM's system. When installed as part of the system packaging, it typically is implemented on one or more boards that reside outside the system's bus slots, but adjacent to the main system's single board computer, as shown in Figure 1.

A typical bare chassis in which these boards would reside is depicted in Figure 2. The functions included in the CMM module depend on application requirements, but a block diagram of a typical module is shown in Figure 3.

For example, a motion control system's single-board computer could act as a host controller. This board might provide analog and digital I/O functions, digital signal processing, and local memory and processing of the motion control algorithm. In a typical system, this controller would interface with motion control boards, such as those providing stepper-motor control, encoder readback, and multiaxis servo control.

At the IC level, the CMM module uses devices with the Inter-IC (I^2C) bus interface, which facilitates interconnection of a wide array of ICs providing peripheral controller functions. The I^2C bus provides data transfer efficiency through a simple protocol format and bidirectional two-wire design, which consists of a serial data line (SDA) and serial clock line (SCL). Multiple masters and slaves are allowed, because the I^2C bus arbitration procedure decides which master gets priority.

This simplicity allows design flexibility while reducing pin count, interconnection costs, and board space. Several "smart sensors" with the I^2C interface are available from National Semiconductor, Dallas Semiconductor, and other manufacturers, and are designed specifically to monitor temperature, fan speed, chassis intrusion and power-supply failure.

Principal Hardware and Software Tasks in CMM Development

Hardware x	Software Tasks
Write Hardware Spec	Write Software Spec
Write Test Plan	Write Test Plan
Part Selection	Configure BIOS Settings
Schematic Capture	Install, Debug, & Test Operating System
Board Layout	Install, Debug, & Test Network Protocol Stack
Board Assembly & Debug	Install, Debug, & Test Web, FTP, & Data Servers
Execute Test Plan	Hardware Setup Programming
Create User Documentation	Develop, Install, Test, & Debug All Drivers*
	Execute Test Plan
	Create User Documentation

* Required drivers include those for Telnet to serial ports, logging, PC bus, contact closure, accumulated uptime and run LED, temperature sensors, voltage sensors, and remote shutdown.

Multiple devices can be daisy-chained on the I^{2}C bus up to a maximum determined by allowable capacitance on the lines—400 pF—and the protocol's addressing limit of 16 k. (Typical device capacitance is about 10 pF.)

At the networking level, an interface to external PCs and workstations is provided through a web server embedded in the CMM module. The server, along with configuration files, data files, etc., are stored on the board's solid-state disk storage device. Data transfers between external devices (outside the system chassis) and the module take place over an appropriate data communications interface (Ethernet, RS-232, etc.). When FTP transfers are used, they go through the CMM module. A Telnet connection can be made to the CMM module, or through that module to the console port of remote equipment.

Outsourcing CMM

To get the maximum benefits from outsourcing CMM, design and purchase specifications should be flexible, as well as the initial design review process. For CMM to be most effective, it is important that the system engineer fully understand the environment in which the end product will be deployed. This includes potential hazards and failure modes to help determine the elements that must be monitored and define user-interface requirements. Communicating this information to system packaging designers will help them determine the appropriate level of CMM and specific features required for the application.

In the case of the inspection system developer mentioned earlier, by switching to a packaging system with built-in Level 3 CMM functions, many of the earlier integration costs were eliminated. For example, software development for this OEM was reduced by more than 75 percent.

Moreover, it was easy to tie the resulting system into the firm's overall inspection monitoring scheme. The Level 3 CMM controller works with individual IP addresses that are unique for each user and inspection system chassis, allowing multiple access anywhere on the network.

Physically, all primary CMM control was implemented on a single 3U × 160-mm board, with on-board Ethernet and RS-232 communication. This board also provides remote sensor control through a simple I^{2}C two-wire bus that drastically reduced hardware integration complexity. The hardware costs of adding the entire Level 3 CMM was roughly the same as the Ethernet-to-RS-232 adapter alone in the original solution.

Since the Level 3 CMM controller has its own independent microprocessor, it is able to communicate directly with the system's CPU console. It also provides this access to remote users, such as service personnel, over a LAN/WAN connection. This allows the user to view diagnostic information and make configuration changes to the CPU operating system and BIOS independent of the CPU network interface.

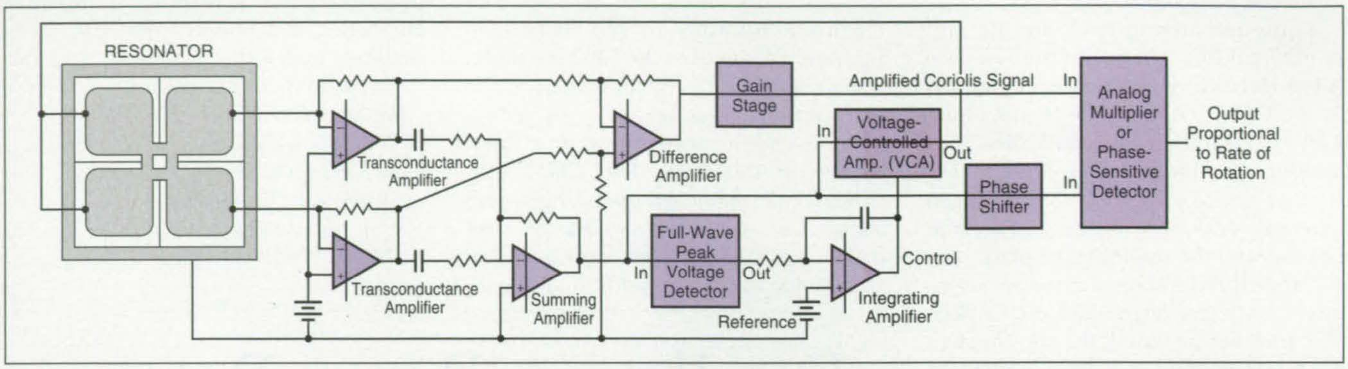
This system also supplies a high degree of flexibility. The CMM controller's open-standard operating system allows fast upgrades to change controller parameters, such as alarm settings, logic states, and additional sensor devices. Since the interface to the CMM is through a standard web browser, no field software changes are required to make these modifications. A system administrator simply changes the webpage configuration directly on the CMM controller and remote users are automatically updated.

For more information contact:
Jay Shumaker
Tracewell Systems, Inc.
567 Enterprise Drive
Westerville, OH 43801
www.tracewellsystems.com;
(800) 848-4525.

Circuit Generates Rotation Signal From a Vibratory Gyroscope

Rotation is measured in terms of a difference between two vibrational velocities.

NASA's Jet Propulsion Laboratory, Pasadena, California



The **Portion of This Circuit That Generates the Rotation-Rate Signal** exploits the sum and difference of the outputs of the transconductance amplifiers. The difference signal is either multiplied by, or detected synchronously with respect to, the sum signal.

This is the first of four articles that address various issues concerning the generation and utilization of electronic signals in the operation of micromachined planar vibratory microgyroscopes and other sensory devices that include electrostatically actuated, capacitively sensed mechanical resonators. The subject of this article is that part of the overall electronic circuitry of a planar vibratory gyroscope that generates a signal proportional to the rate of rotation.

Some background information is prerequisite to a description of this circuitry and to the descriptions of the circuits described in the following three articles. Various aspects of micromachined planar vibratory microgyroscopes have been described in a number of previous articles in *NASA Tech Briefs*. The basic principle of operation is as follows: Four planar silicon plates are connected together by silicon springs in a symmetrical pattern resembling a clover leaf. The silicon springs lie at the center of the pattern. When in equilibrium (not vibrating), all plates lie in the same plane.

Together, the plates and springs constitute a mechanical resonator characterized by two orthogonal degenerate modes of vibration. Two of the plates are driven electrostatically to generate oscillations in one of these modes, denoted the driven mode. The oscillatory displacements or velocities of all four plates are measured by use of capacitive sensors.

One seeks to measure rotation about the axis perpendicular to the equilibrium plane of the resonator plates. The Coriolis force associated with this rotation couples energy from the driven mode to the other mode, denoted the sensing mode, in which there is a difference between the velocities of the two plates that are not driven electrostatically (the sensing plates). This difference between velocities gives rise to a corresponding difference between the outputs of the capacitive sensors for the sensing plate. The difference signal, called the "Coriolis signal," is proportional to (1) the amplitude of oscillation of the driven plates; (2) the rate of rotation, Ω; and (3) the resonance quality factor, Q, which is inversely proportional to the rate of damping of vibrations.

The circuitry in question is designed to generate a signal proportional to the Coriolis signal and thus to Ω. This circuitry is part of the overall circuit shown in the figure. As explained in more detail in the following article, the inputs to the transconductance amplifiers are the raw velocity signals from the sensing-plate capacitors. Thus, the difference between the outputs of the two transconductance amplifiers contains the desired information.

Because of common-mode rejection, the sum of transconductance-amplifier outputs, which is proportional to the driven-mode velocity signal, contains no information on Ω. If the magnitude of oscillation is held constant as described in the following article, then the sum signal has a constant magnitude. In any event, the sum signal is used as a reference for phase-sensitive detection of the difference signal. In one version of this circuitry, the difference signal is multiplied by a 90°-phase-shifted replica of the sum signal. In another version, the difference signal is synchronously detected, using the phase-shifted sum signal as the timing reference. In either version, the time-averaged output signal is proportional to ΩQ.

This work was done by Christopher Stell, Vatché Vorperian, Roman Gutierrez, and Tony Tang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components & Systems category. NPO-20087*

Vibration-Regulating Circuit for a Mechanical Resonator

A two-loop feedback system maintains constant magnitude of vibration.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure illustrates an improved electronic circuit that excites constant-magnitude vibrations in an electrostatically actuated, capacitively sensed mechanical resonator. The circuit can be adapted, for example, to a planar vibratory microgyroscope like the one described in the preceding article.

Mounted on the moving part of the resonator are two electrodes — the driven and the sensing plates — that face corresponding fixed driven and sensing plates. Each pair of electrodes serves as a capacitor; the driven one for electrostatically exciting vibrations, the sensing one for measuring the vibrational velocity. Through the negative-feedback path of the transconductance amplifier, the fixed sensing plate becomes charged up to the dc bias applied to the "+" terminal of the transconductance amplifier. As

Think it.

With National Instruments motion control products, you get all the benefits of graphical programming – plus, software tools to help you get the job done faster, increase productivity, and simplify motion control system development.

Wire it.

Create and develop one-of-a-kind or OEM systems with flexible and easy-to-use software tools. NI offers the most advanced motion control software, including interactive development software, comprehensive function libraries, and detailed examples for Microsoft Visual Basic and LabVIEW™.

Move it.

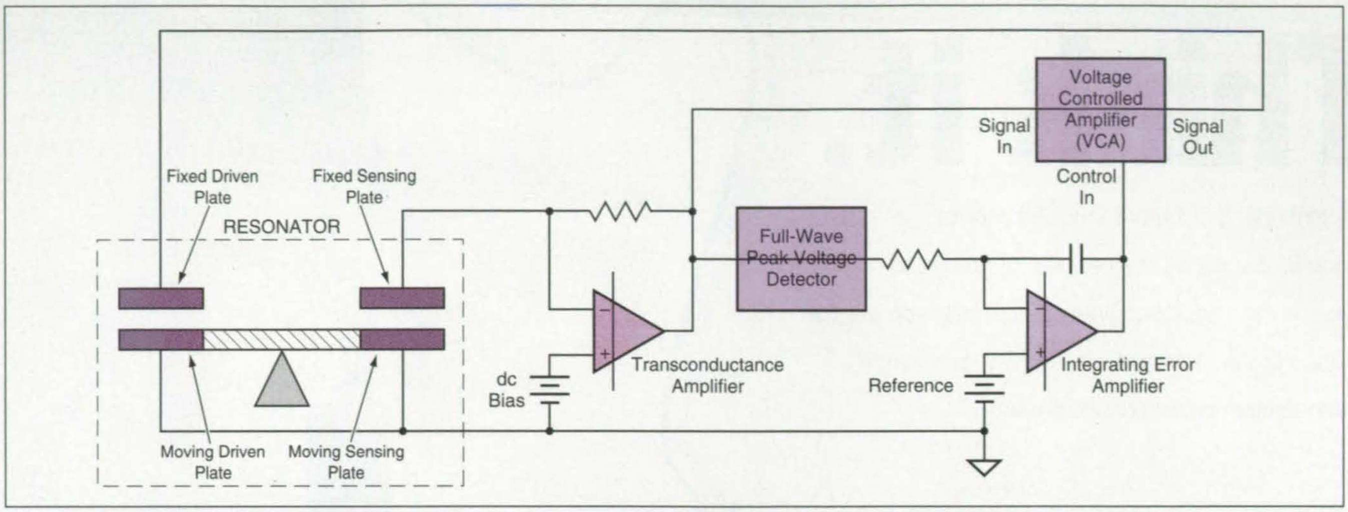
Power and simplicity are at your fingertips. Increase productivity and performance with simplified motion control system development from National Instruments.

NATIONAL INSTRUMENTS™

ni.com/info/motion **(800) 811-0742**

Tel: (512) 794-0100 • Fax: (512) 683-9300 • info@ni.com

For More Information Circle No. 602



The **Mechanical Resonator Is Part of an Oscillator Circuit** and determines the frequency of oscillation. The gain of the VCA is continually adjusted to regulate the magnitude of the capacitively sensed mechanical oscillations.

the resonator vibrates, the voltage across the sensing capacitor thus remains constant, although its capacitance varies at a rate proportional to the vibrational velocity. By the fundamental relationship among capacitance, voltage, and charge, a current proportional to the vibrational velocity must therefore flow between the sensing plate and the "-" input of the transconductance amplifier. As a result, the transconductance amplifier puts out a voltage proportional to the vibrational velocity.

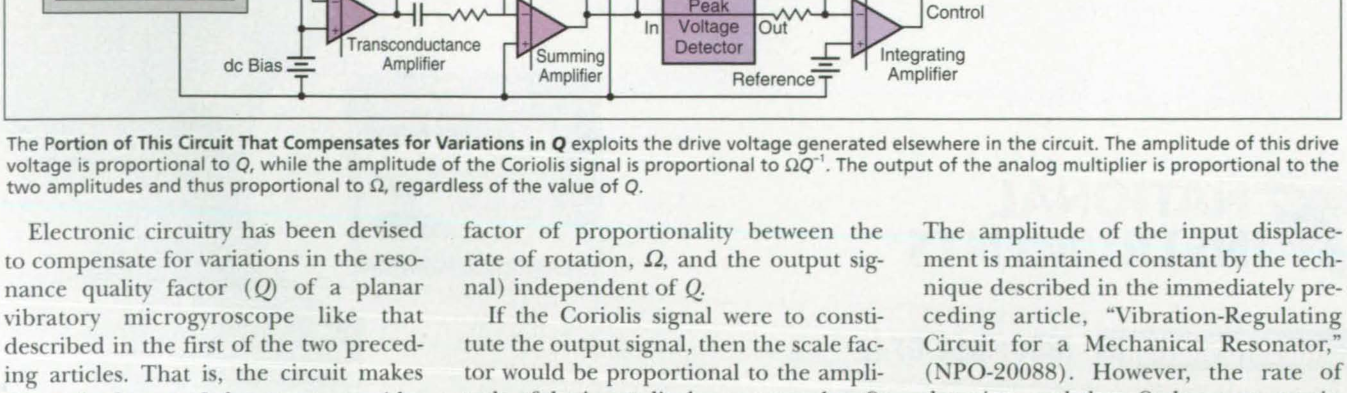
The output of the transconductance amplifier is fed to the signal-input terminal of the voltage-controlled amplifier (VCA) and to the input terminal of the full-wave peak detector. The integrating amplifier produces an error signal that is the integral of the difference between (1) the peak-detector output (which is proportional to the magnitude of the vibrational velocity) and (2) the reference voltage, which represents a desired magnitude of vibration. The error signal is fed to the control-input terminal of the VCA. The output of the VCA is proportional to the velocity and is fed back to the fixed drive plate. With sufficient gain in the amplifiers, the resonator and feedback loop oscillate together. When the amplitude of oscillation is too high or too low, the error signal adjusts the gain of the VCA to drive the magnitude of vibration toward the desired value represented by the reference voltage.

This work was done by Christopher Stell, Vatché Vorperian, Roman Gutierrez, and Tony Tang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components & Systems category. NPO-20088*

Q-Compensation Circuit for a Planar Vibratory Microgyroscope

The amplitude of the resonator-drive waveform is used to make the output independent of Q.

NASA's Jet Propulsion Laboratory, Pasadena, California



The **Portion of This Circuit That Compensates for Variations in Q** exploits the drive voltage generated elsewhere in the circuit. The amplitude of this drive voltage is proportional to Q, while the amplitude of the Coriolis signal is proportional to ΩQ^{-1}. The output of the analog multiplier is proportional to the two amplitudes and thus proportional to Ω, regardless of the value of Q.

Electronic circuitry has been devised to compensate for variations in the resonance quality factor (Q) of a planar vibratory microgyroscope like that described in the first of the two preceding articles. That is, the circuit makes the scale factor of the gyroscope (the factor of proportionality between the rate of rotation, Ω, and the output signal) independent of Q.

If the Coriolis signal were to constitute the output signal, then the scale factor would be proportional to the amplitude of the input displacement and to Q. The amplitude of the input displacement is maintained constant by the technique described in the immediately preceding article, "Vibration-Regulating Circuit for a Mechanical Resonator," (NPO-20088). However, the rate of damping, and thus Q, does not remain constant; the rate of damping is very sensitive to the density and pressure of the fluid in which the resonator is immersed. Thus, there is need for further processing of the Coriolis signal through circuitry like that described below to make the scale factor remain constant despite variations in Q.

The circuitry in question is part of the overall electronic circuit shown in the figure. To maintain a constant input vibration amplitude, it is necessary to drive the resonator with a voltage proportional to Q. Other parts of the circuit generate such a drive voltage, which is applied not only to the resonator but also to the input terminal of a 90° phase shifter. The output of the phase shifter is fed to one of two input terminals of an analog multiplier. An amplified version of the Coriolis signal is applied to the other input terminal of the analog amplifier. Because the Coriolis signal is approximately 90° out of phase with the drive signal, it is approximately in phase with the output of the phase shifter. Therefore, the time-averaged output of the analog multiplier is proportional to the amplitude of the Coriolis signal (proportional to ΩQ) and to the amplitude of the drive signal (proportional to Q^{-1}). Thus, the output of the analog multiplier is proportional to Ω only, as desired, regardless of variations in Q.

This work was done by Christopher Stell, Vatché Vorperian, Roman Gutierrez, and Tony Tang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components & Systems category. NPO-20089*

Motion-Measuring Circuit for a Vibratory Capacitive Sensor

This circuit offers some advantages over circuits designed previously for the same purpose.

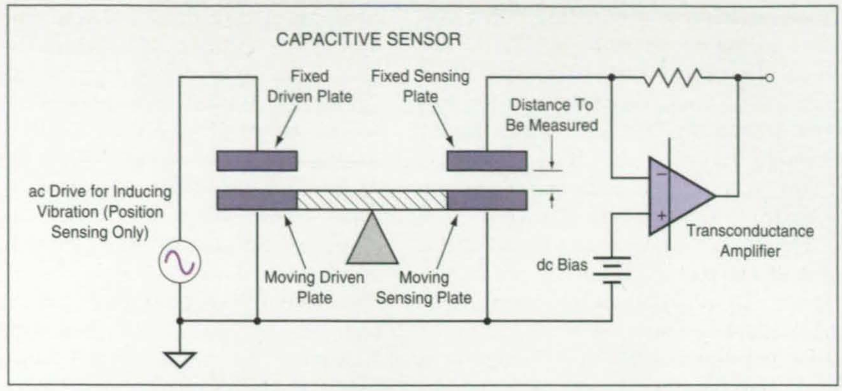
NASA's Jet Propulsion Laboratory, Pasadena, California

The figure illustrates an improved electronic circuit that generates a signal proportional to either the instantaneous vibrational velocity or the instantaneous position (equivalently, the instantaneous vibrational displacement) of a vibratory capacitive sensor of the type discussed in the three preceding articles. This circuit offers some advantages over circuits designed previously for the same purpose; in particular, there is no need for a reference capacitor, and the circuit is insensitive to capacitive loading of its sensing amplifier.

The vibratory sensor includes a resonator equipped with capacitor electrodes in a manner similar to that of the vibration-regulating scheme described in the second of the preceding articles: Mounted on the moving part of the resonator are two electrodes — the driven and sensing plates — that face corresponding fixed driven and sensing plates. Each pair of electrodes serves as a capacitor; the driven one for electrostatically exciting vibrations, the sensing one for measuring the vibrational displacement or velocity.

Also as in the vibration-regulating scheme, the negative-feedback path of the transconductance amplifier is utilized to maintain the fixed sensing plate at a voltage equal to the dc bias applied to the "+" terminal of the transconductance amplifier. Therefore, in the absence of additional vibratory and/or electronic inputs, this circuit behaves similarly to the corresponding part of the vibration-regulating circuit; namely, the instantaneous output of the transconductance amplifier is a voltage proportional to the instantaneous vibrational velocity.

Additional vibratory/electronic input is necessary to obtain a position signal. In particular, a voltage alternating at a frequency much greater than that of the vibration to be measured is applied to the driven plates to excite a superimposed sinusoidal vibration much smaller than the vibration to be measured. This small, high-frequency vibration gives rise to a velocity signal in the manner described above. The capacitance varies with the position of the sensing plate in a known way, and the magnitude of the velocity signal varies in proportion to the change in capacitance. Thus, the instantaneous magnitude of the velocity signal serves as an indicator of the instantaneous position of the sensing plate.



This **Circuit Provides an Indication** of either the instantaneous velocity or the instantaneous position of the sensing plate, depending on the choice of operational mode as described in the text.

This work was done by Christopher Stell and Vatché Vorperian of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components & Systems category. NPO-20086*

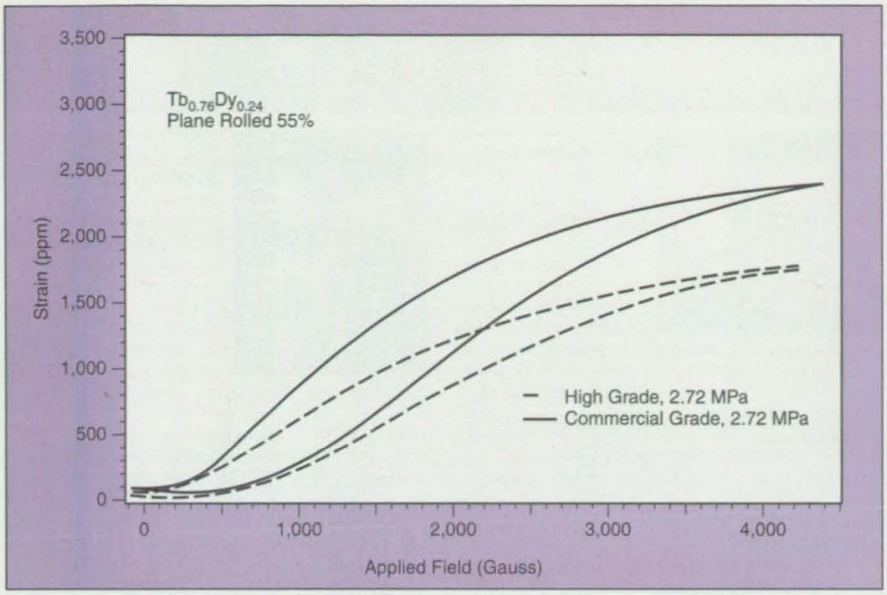
Using Commercial-Grade Tb/Dy in Magnetostrictive Actuators

This material would offer performance and cost advantages over purer material.

NASA's Jet Propulsion Laboratory, Pasadena, California

Single crystals of Tb-Dy alloys exhibit magnetostrictive strains approaching 1 percent and can generate forces sufficiently large to make them useful as actuators in cryogenic mechanical devices. These actuators offer many advantages over piezoelectric actuators and actuators using motion feedthroughs from higher temperature. Unfortunately, the preparation of single crystals of Tb-Dy alloys is difficult and costly, and will likely remain so. The limited availability of single crystals could impede the development of this new actuator technology. Since polycrystals are much simpler to prepare and are less costly, textured polycrystalline materials are being developed as alternatives to single crystals, as discussed in "Polycrystalline Tb/Dy Alloy for Magnetostrictive Actuators" (NPO-20273), *NASA Tech Briefs*, Vol. 23, No. 8, (August 1999), page 44. Continued efforts to reduce the cost of magnetostrictive polycrystals have led to the use of lower-cost commercial grade (total purity 99.7 percent) Tb-Dy material [as opposed to expensive high-purity (99.94 percent) material required for the growth of single crystals].

In general, a material containing many individual crystals with random orientation will not have a large bulk magnetostriction. Crystallographic texture describes the average orientation of the individual crystallites in the material. It is possible to achieve a preferred texture by various materials-processing methods, but one of the simplest is deformation processing. The Tb-Dy alloy was arc-melted and drop-cast into a chilled copper mold. Since the as-cast ingot shows strong crystallographic texture, the material was first cold rolled to a 35-percent reduction in thickness and heat treated for 1.5 h at 950 °C to induce recrystallization. This step was intended to provide a random initial orientation of spherical grains, although our bulk thermal expansion measurements indicate that significant texture remained after this step. The specimen was then plane-rolled by 55 percent and annealed at 350 °C to relieve strain. This rolling and annealing combination was performed once or repeated a number of times. It can be seen in the figure that the commercial specimen exhibits 2,400 ppm magnetostriction, while the high-purity specimen exhibits only 1,750 ppm magnetostriction. It may be that the additional impurities in the commercial-grade material limits grain boundary growth during heat treatments, and studies are cur-



Strain Versus Applied Field is shown for commercial-grade and high-purity polycrystalline Tb-Dy.

rently underway to relate grain size and texture to magnetostriction. Although impurities that inhibit grain growth are detrimental to the fabrication of single-crystal materials, these impurities may not be a problem for polycrystalline materials. The use of Tb and Dy of lower purity may be an important practical advantage of polycrystalline materials, since the lower-purity materials can be obtained at significantly lower cost and with greater reliability.

This work was done by Jennifer Dooley and Brent Fultz of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to: Technology Reporting Office., JPL, Mail Stop 122-116, 4800 Oak Grove Drive, Pasadena, CA 91109. (818) 354-2240

Refer to NPO-20697, volume and number of this NASA Tech Briefs *issue, and the page number.*

Pulse-Mode Reaction Control System Thruster

This thruster burns nontoxic propellants.

Lyndon B. Johnson Space Center, Houston, Texas

A spacecraft reaction-control-system (RCS) thruster now undergoing development generates a thrust of 870 lbf (3,870 N) by burning ethanol and liquid oxygen (LOX), which are nontoxic. The performance of the thruster has been tested in operation in multiple pulse modes with pulses as short as 160 ms; such pulses are typical of those required for the space-shuttle RCS.

This test is the first successful demonstration of a liquid/liquid-fed thruster in pulse-mode operation. The use of thrusters fed by nontoxic liquids is expected to afford great benefits — not only in space-shuttle operations but also in the operations of reusable first-stage or liquid-fueled fly-back boosters or, indeed, of any reusable launch vehicle currently produced by NASA or the Department of Defense.

Today, the market for thrusters like this one is limited to the second-stage RCS and orbital maneuvering system of the Kistler K-1 vehicle (a commercial reusable launch vehicle), to the RCS of the VentureStar reusable launch vehicle, and to upper-stage RCSs in general; however, with the increase in the number of commercial aerospace companies launching unmanned rockets, the technological advances made in the development of this thruster can be expected to affect the commercial field significantly. For NASA, the use of LOX and ethanol in the shuttle RCS thrusters will not only increase safety but will also reduce costs.

This work was done by Paul Philipsen, Lee May, and Ross Hewitt of GenCorp for **Johnson Space Center**.

MSC-23017

New Products

Motion Control System

Delta Computer Systems, Vancouver, WA, has announced the addition of a high-versatility motion controller to its RMC family of motion modules. The DIN-rail mounted controller includes a quadrature encoder interface for positive control of motors and linear actuators, and a Synchronous Serial Interface module for immunity from noise, high resolution, and absolute positioning, while allowing the use of transducers, absolute encoders, and laser measuring devices from various manufacturers. Other features include a 16-bit analog interface, an -A1, 12-bit module featuring four isolated 12-bit inputs, and the TCP/IP Ethernet industrial network protocol for PLCs.

For More Information Circle No. 752

AC Inverter for Motor Control

The SYSDRIVE JV series of AC inverters from Omron Electronics, Schaumburg, IL, features a digital operator that utilizes quick-start LEDs for easy programming. The digital operator comes with a face-mounted speed potentiometer that makes it possible to start the inverter immediately after power is applied. The inverters measure 5" high, and can be mounted on an optional DIN rail bracket. They can be used for motor control in pumps, fans, conveyors, mixers, blowers, and compressors. Other features include soft start and optional RS-422 and 485. The inverters offer V/Hz control with a starting torque of 150% at 3 Hz.

For More Information Circle No. 753

Robotic Automation System

Viscotek, Houston, TX, has introduced a laboratory automation system with a seamless integration of the company's Relative Viscometer with the Zymark robotics hardware for complete automation of the solution viscosity testing process. The operator presents the sample to the robot and is then free to do other tasks. The robot prepares each sample the same way, every time, without operator subjectivity and variability in preparation method. The robot continually checks for new samples, and has increased throughput of 10 to 15 minutes per sample, depending on the number of capping operations necessary for the samples.

For More Information Circle No. 754

Integrated Motor and Controller

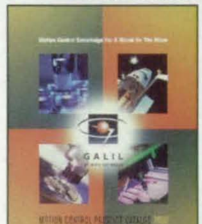
The Series 3564 BC from Micro Mo Electronics, Clearwater, FL, integrates a brushless DC motor, amplifier, and full-function motion control module. It combines a System Faulhaber® coil, precision machining and molding, and design miniaturization with a single-chip microcomputer, Hall sensor technology, new control algorithms, and digital filtering techniques. In addition to motion, velocity, and position control, the drive also is capable of torque control, stepping mode operation, and variable fault protection programming. It is available with a range of gearheads, from 3.71:1 to 1,526:1 in planetary and spur constructions.

For More Information Circle No. 755

Motors and Gearmotors

Pittman, Harleysville, PA, offers the LO-COG® Series 8290™ 26-mm brush-commutated DC motors and gearmotors that feature a cartridge brush assembly designed to reduce audible and electrical noise. The 26-mm iron-core motors and gearmotors are available in three lengths: 1.798", 1.923", and 2.173". They feature a 7-slot skewed armature to minimize magnetic cogging, even at low speeds, and windings are resin-impregnated for reliability in incremental motion applications. Two-pole permanent magnet stators are made of bonded neodymium iron boron magnets. The units can be customized with Hewlett-Packard optical encoders.

For More Information Circle No. 756



Motion Control Products

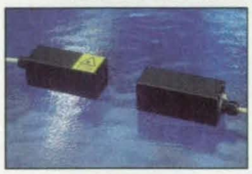
Galil Motion Control, Mountain View, CA, offers a 96-page catalog of motion control products, including the Optima, Econo, and Legacy Series controllers. The catalog features DMC-based controllers and provides a motion controller comparison table. Interface options include ISA, PCI, CompactPCI, PC/104, VME, RS-232, USB, and Ethernet. One- through eight-axis versions are available with interchangeability of steppers and servo motors on any axis. A 20-page technical reference guide includes an overview on motion control, including elements of a servo system, tuning, and programming.

For More Information Circle No. 757

Brushless Motors for Automotive

MFM brushless two-wire motors for automotive OEM applications are available from Bayside Motion Group, Port Washing-ton, NY. The motor/amplifier combination features an integrated two-wire brushless design and an integrated encoder. The motors allow substitution of longer-life DC brushless motors for DC brush-type motors. Commutation is integrated into the motor, allowing usage off standard battery voltage.

For More Information Circle No. 758



Laser-Based Gauging Sensors

The Class II and Laser Beam Sensors from LMI Selcom, Detroit, MI, are noncontact laser-based industrial gauging sensors based on the shadow measurement principle. Available in 15 standard models and diaphragms, the sensors look at the shadow they create, and do not rely on surface reflectivity for measurement. They are suited for high-speed, nonstationary, hard-to-measure applications in rubber, metalworking, aluminum, paper, and plastics. The sensors consist of an emitter and receiver, and allow measurement independent of the object in the beam. Measurement range varies from 0.02" to 1.0"; frequency ranges from 1 to 10 kHz.

For More Information Circle No. 760

Motor-Driven Pump

The DP0105 DC motor-driven pump from Medo USA, Hanover Park, IL, provides vacuum and pressure, and features a cup-seal design to attain a vacuum in excess of 10" Hg, and a maximum pressure of 36 psig. The pump is suitable for use in gas analyzers, endoscopes, blood pressure monitors, and other types of transportable medical equipment. The pump is available in 12V or 24V DC and has a life expectancy of 1000 hours.

For More Information Circle No. 762

Electric Motors and Drives

Baldor Electric Co., Fort Smith, AR, has expanded its line of Inverter Drive® and Vector Drive® motors that meet or exceed NEMA MG1-1998, Part 31 requirements. The motors feature Totally Enclosed Non-Ventilated (TENV) ratings through 20 HP, Totally Enclosed Blower-Cooled (TEBC) ratings through 800 HP, and washdown duty motors through 10 HP. The Inverter Drive motors are approved for explosion-proof environments. The motors all feature the Inverter Spike Resistant (ISR®) magnet wire that is up to 100 times more resistant to transient voltage spikes, high frequencies, and short rise time pulses produced by adjustable speed controls.

For More Information Circle No. 761

Autoclaveable Brushless Motors

Transicoil, a division of Horizon Aerospace, Norristown, PA, has introduced autoclaveable brushless DC motors for use in powering medical instruments and other applications where surviving autoclave cycles is critical. The motors are available in Sizes 5, 8, and 10, with operating voltages of 12 to 48V DC and speeds of 3000 to 100,000 rpm. Gearheads are available in Sizes 5 and 8, with ratios of 3:1 to 256:1. The company says that the motors maintain their performance after going through 1,000 autoclave cycles. They feature stainless steel housings, hollow shaft designs, and Hall Effect devices rated -55 to +150 °C.

For More Information Circle No. 763

Vol. 24, No. 6 June 2000 This form expires: November 30, 2000

Fast Fax Information Form

Fax: (413) 637-4343

Fax this form for quickest processing of your inquiry, or use the on-line LeadNet Service at www.nasatech.com. (Click on: "Get More Information...FAST")

Name: ______________________________

Company: ______________________________

Address: ______________________________

City/St/Zip: ______________________________

Phone: ____________________ Fax: ____________________

e-mail: ______________________________

Circle the numbers below to receive more information about products and services featured in this issue.

401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420
421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440
441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460
461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480
481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500
501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520
521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540
541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560
561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580
581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600
601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620
621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640
641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660
661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680
681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700
701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720
721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740
741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760
761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780
781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800
801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820
821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840

ARE YOU AN INSIDER?

Subscribe today to receive the INSIDER, a FREE e-mail newsletter from *NASA Tech Briefs*. The INSIDER features exclusive previews of upcoming articles…late-breaking NASA and industry news…hot products and design ideas…links to online resources…and much more.

❑ I want to be an INSIDER. Send my newsletter to the following e-mail address:

____

Name ______________________________

Company ______________________________

I also want to receive special-focus e-newsletters on the following technology topics: (check all that apply)

❑ CAD/CAE
❑ Lasers
❑ Fiber Optics/Communications
❑ Test & Measurement
❑ Optics
❑ Imaging/Cameras

For fastest service, sign up online at www.nasatech.com.
Look for this button at the top of the home page ⇨

Math Software Models Motions of Space Station System

Maple® mathematical/analytical software
Waterloo Maple
Waterloo, ON, Canada
519-747-2373
www.maplesoft.com

MATLAB computation/simulation software
The MathWorks
Natick, MA
508-647-7000
www.mathworks.com

The International Space Station, the largest international scientific program ever, is being built jointly by Canada, the United States, Russia, Japan, and 11 European countries. At the heart of the assembly operation is Canada's Mobile Servicing System (MSS), a complex manipulator that includes robot "arms" that can pick up and manipulate everything from delicate objects to large payloads. Being built and tested at the Canadian Space Agency (CSA) facilities in Saint-Hubert, Quebec, the MSS will be used to unload equipment from the space shuttle, move heavy objects, help assemble the space station, and then maintain it afterwards.

The MSS includes a main arm (the Space Station Remote Manipulator System, or SSRMS), a smaller manipulator with two arms (the Special Purpose Dexterous Manipulator, or SPDM), and the Mobile Remote Servicer Base System (MRSBS). The SSRMS is a 15-meter long, seven degrees-of-freedom manipulator with flexible joints and booms. The smaller arm has two 3.5-meter long arms that allow very fine motion for delicate tasks. Each arm has seven actuators, and the entire assembly has 22 rigid degrees of freedom and more than 30 flexible ones.

At the end of each of the SPDM arms is an Orbital Tool Change-Out Mechanism, which includes a gripper, a camera and two lights, a socket drive mechanism, and a force moment sensor. In a typical task, the SSRMS will move the SPDM to a location where maintenance needs to be performed. One arm of the SPDM will grasp a stabilization point, creating a closed kinematic loop. The other arm will delicately remove and replace a part on the space station — a task involving contact dynamics.

Testing such a task could be a nightmare, but the CSA has had a great deal of experience with manipulators ever since it built a robot arm for the first space shuttle. "Over the past 20 years, CSA has developed modeling and simulation tools for off-line and real-time simulation of space manipulators," said Dr. Jean-Claude Piedboeuf, manager of robotics at the CSA. For the MSS, Piedboeuf's group has to verify that every operation will work. "The actual hardware is so light that it cannot support its own weight here on Earth. So we have to simulate and emulate everything in software," Piedboeuf explained.

To verify contact dynamics actions, CSA is building the SPDM Task Verification Facility that uses an earth-bound robot modified to perform similar dynamic behavior to the SPDM. The simulation is performed using the dynamic engine of a real-time Mobile servicing system Operation and Training Simulator (MOTS). The simulator's design is based on CSA's SYMOFROS software for flexible dynamic modeling. Used in conjunction with SYMOFROS are Maple software from Waterloo Maple; MATLAB, Simulink, Stateflow, and Real-Time Workshop software from The MathWorks; LabVIEW from National Instruments; and RT-LAB from Opal-RT Technologies.

The SSRMS during its development at Spar Aerospace in Brampton, Ontario. (Image courtesy of the Canadian Space Agency. ©Canadian Space Agency 2000)

SYMOFROS is used to develop the robot dynamic models required for the simulation and the real-time control of the manipulator. It is based on Maple for symbolic model generation, and MATLAB and Simulink for real-time simulation.

First, every mechanism in the manipulator must be defined as an object, with information describing all the forces associated with the object's motion or tasks. This includes rotation and position matrices, center of mass, inertia, external torque and forces acting on it, gyroscopic effects, beam deformations, internal damping, motor torque, and elastic torque.

Next, an operator must construct a graphical model, using a MATLAB-Simulink program to describe the robot system's topology. The operator drags and drops object blocks from a library, links them together, and then downloads the result to the Maple engine.

The dynamics equations are built following Jourdain's principle, which is a variational method in which constraint forces are eliminated. The Maple part of SYMOFROS obtains kinematics and dynamics recursively and models the flexible beams using Euler-Bernoulli approximations. By consistently eliminating high order terms, it generates equations of motion that are exact to the first order.

When the Maple software completes its symbolic linearization of the model and generates the C functions that will be needed for simulation and control, it then optimizes the C code. The generated code can now be compiled and loaded into MATLAB and Simulink systems for execution.

Measuring the benefits of the software is very difficult, mainly because the task could not have been done any other way. Fortunately, now that the SYMOFROS system is running, the R&D department of CSA can use it for a wide variety of tests.

The SSRMS was delivered to NASA last year and is now being tested at Kennedy Space Center's Space Station Processing Facility in Florida.

For More Information on Waterloo Maple Circle No. 744
For More Information on The MathWorks Circle No. 745

We Did It!

That's right: we've take portable data acquisition to a whole new level. The DEWE-3010 and DEWE-2010 completely redefine what a data acquisition system should be. Not just portable a rugged, but also open-architecture, so you can upgrade the hardware and software long into the future. With modular signal conditioners you can mix and match to create your own system with dozens of fast channels and up to 2048 slow/temperature channels!

Plug-in DEWE-MODULES

DEWE-RACK-16 and any PC

DEWE-3010 Ultra-portable complete system

- MIL-STD-810 Shock/Vib*
- Includes DEWEScope+ Software
- Plug-in DEWE-MODULES
- Front-ends for any A/D card
- Complete stand-alone systems

Our DEWEScope+® software makes setup and recording easier than ever. Want to use DASYLab® or LabVIEW®? No problem - our open-architecture platform runs them all (and more) without a hitch. Trigger and capture effortlessly to disk at rates up to 1.25 MHz. With plug-in modules for direct connection of every sensor – DC and AC strain gages, charge and ICP® accelerometers, microvolts to kilovolts, RTD's and thermocouples (9 types), LVDT's, string pots, RPM and TACH signals from engines and turbines, and more.

With 1000V isolation, exceptionally low noise, and multiple range/filter selections in each plug-in module! Dewetron builds rack-mounted and portable systems for a wide variety of applications in the automotive, aerospace, industrial, process control, research, chemical, medical research, and other industries. Find out what so many others have already discovered—for a no-obligation demo, please contact us today at **1-401-782-3866**, visit our website, or send an email to: **justdewit@dewamerica.com**

TÜV CERT ISO 9001 · TÜV BAYERN EN ISO 14001 · CE

DEWETRON

Dewetron, Inc.
18 South Glen Court
Wakefield, RI 02879-7690
Tel: 1-401-782-3866
www.dewamerica.com

AMERICA • AUSTRIA • BELGIUM • GERMANY • NETHERLANDS • SLOVENIA • THE CZECH REPUBLIC • THE U.K.

 * Certain CDROM drives do not meet MIL-STD specifications

For More Information Circle No. 533

Cadmium Zinc Telluride Detectors for Imaging of Gamma Rays

With a suitable choice of parameters here, it should be possible to image hard x-ray and gamma-ray radiation sources at angular resolutions of 30 arc seconds and finer.
(See page 44.)

Inexpensive Packaged Subharmonic Down-Converter MMICs

Two packaged monolithic microwave integrated circuit (MMIC) mixers are designed to operate as subharmonically pumped frequency down-converters in receivers of satellite- or ground-based digital communication systems. The approach taken is to minimize costs by using established design practices and fabrication technologies.
(See page 46.)

Power Supply for Miniature Quadrupole Mass Spectrometer

This power supply generates a combination of RF and dc voltages needed for the operation of remotely located spectrometers. The spectrometers could operate unattended for a long time.
(See page 48.)

Vapor Corrosion Cell

This cell detects corrosive gases during their formation as a result of combustion or other processes. The device could be used to monitor air pollution in and outside industrial facilities.
(See page 54.)

RS-232-to-Infrared Transceiver

This transceiver serves as a data-communication link between the RS-232 serial communication port of a personal computer and a remote infrared transceiver running at ≤ 4 MHz.
(See page 60.)

"Intelligent" Transceivers Would Predict Failures of Parts

Miniature "intelligent" transceivers are proposed that would monitor valuable pieces of equipment, predict impending failures, and order parts to avert such failures.
(See page 62.)

Network Based on Stack-Tree Topology and a 1394 Bus

A method of designing fault-tolerant networks of computers and other electronic circuits minimizes costs by utilizing commercial off-the-shelf products and standards for all system and component interfaces.
(See page 64.)

Leveraging Intellectual Assets to Streamline Product Design

Design re-work is happening at an alarming rate of more than 65% in most companies — simply because they did not know that a problem already had been solved. To truly leverage a company's knowledge, a fully automated technology is required to keep up with the information being created.

Getting the most out of your company's intellectual assets serves two critical functions for technology companies. First, finding technology to complete a product design without "re-inventing the wheel," and second, licensing technology to create an additional revenue stream. A few larger companies have made intellectual property (IP) licensing a billion-dollar-per-year contribution to their bottom line. Without truly knowing the content of your intellectual property, you are at risk of missing a chance to exceed revenue goals. Intellectual property evaluation is a daunting challenge using today's traditional methods of reading, sorting, and key-word indexing. Nonetheless, it is an essential requirement for companies to "discover what they know" to avoid costly re-work, and to find extended life for their past discoveries, thus growing revenue.

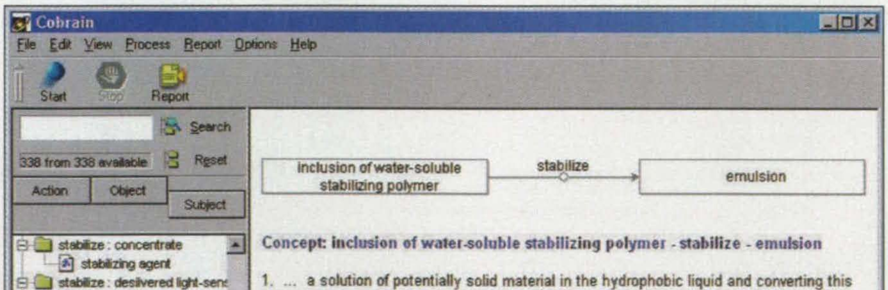
Getting Started

The traditional first steps in intellectual asset evaluation involve getting all documents into electronic format for on-line access, and the use of document management tools that help to organize documents by titles and indexed key words. There are many firms that provide document conversion services using scanners and optical character recognition software (OCR). A company provides filing cabinets filled with paper, and the document-conversion firm returns digital documents (along with the originals, of course).

The next step is to load the documents onto computer servers, adding them to the existing on-line document set, making them available on the company Intranet. Here is where document management tools can help. They provide an infrastructure and organization to storing documents. These tools also provide user-based access and security, and can track revisions and many other statistics. Setting up the file system becomes a daunting challenge because you soon find out that you will need to create hundreds of folders that may contain hundreds of sub-folders that may contain thousands of files.

Luckily, there has been some development of automated categorization tools. These tools examine the title, and may even extract key words from the text to determine where to place the documents. A key-word directory may even be set up for searching, but as you might imagine, a simple search may yield hundreds or thousands of documents containing those key words. This is similar to what happens when you try a search on the Internet, although not as bad.

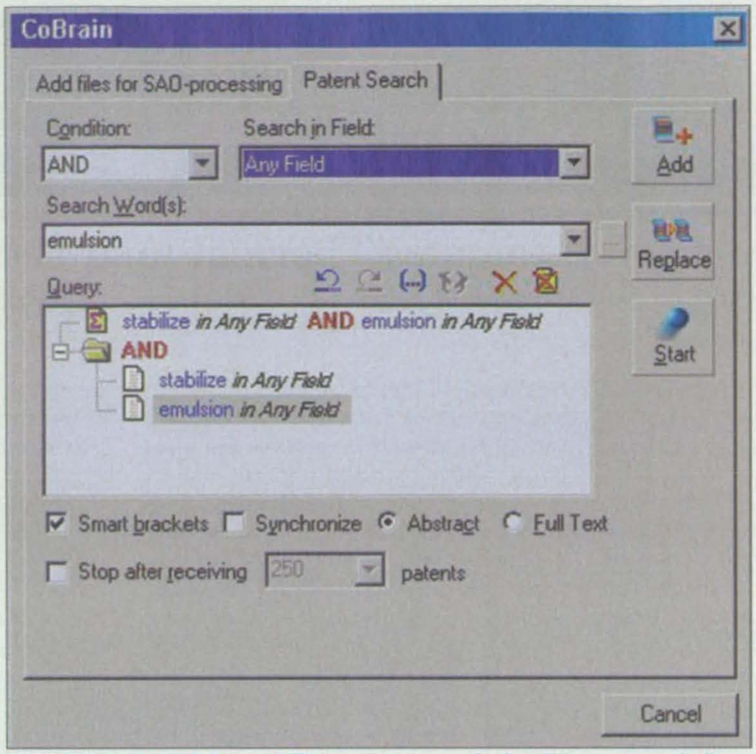
Now a critical question arises. Are you searching for documents or for answers? If you focus on IP assessment, you are looking for all solutions to a specific problem, so you can understand your expertise in a particular area. For example, how to detect infrared light, or reduce vibration, or deposit thin film. On-line files and document management may appear to be a good start, but ultimately companies need the ability to automatically extract and organize all the key concepts within their entire intellectual property portfolio. Since this information is doubling every seven months, automation is very critical to success.



CoBrain processes documents at 1MB/minute, and creates a problem-solution index. In this example, there are four solutions to stabilize an emulsion. The water-soluble polymer solution is selected, and a brief excerpt, along with a link to the original document, appears.

Automated IP Assessment

Semantic processing technology holds the key. Semantic knowledge processing software addresses the needs of Information Technology (IT) departments, knowledge managers, R&D teams, and IP professionals. Programs such as CoBrain™ from Invention Machine Corporation (Boston, MA), are fundamentally designed to read on-line text documents, analyze sentences to determine meaning, extract all key concepts, and automatically create the content and index for an Internet or Intranet portal. The content is organized by functionality, which is ideally suited for intellectual property assessment, as you will find all solutions to any specific problem within a single folder of the index. This index is based on meaning, so queries will return answers. The problem-solution format is suited to the design community, as they are looking to find solutions to their tasks.



Patents from the U.S. Patent Office server are searched and then automatically structured in an SAO tree.

For example, using the older technologies available, an engineer or scientist would key-word search their Intranet repositories or the Internet for ways to reduce friction or deposit thin film, and all too often tens of thousands of items are listed. It then takes hours or even days to wade through this information to find any relevant knowledge. On the other hand, knowledge processing software has an understanding of words, contexts, and relationships, so the multi-pass reasoning and semantic algorithms will extract all key concepts and create a problem-solution index. Now, designers can post a query and get specific answers to their questions, as well as find other experts within their company. First, the company sees a productivity increase, and then a way to start new projects based on existing work, thus avoiding costly re-work.

Designers can post a query and get specific answers to their questions, as well as find other experts within their company.

This knowledge index gives a clear understanding of their IP, and allows the company to more easily determine what could be licensed. For example, a company can see all of their solutions for reducing friction, such as carbon-coating, graphite, graphite fibers, and oil. A brief review could reveal that carbon-coating technology is not being used, and could be licensed easily to third parties. Or, they may see multiple generations of a singular technology and be able to determine if first- or second-generation solutions can be licensed, now that they are using a third- or fourth-generation technology.

Without knowing the company's complete technology portfolio, organized into a functional index, it would be a long and difficult process to begin IP licensing, and probably is why so few companies take advantage of it. The index alone may not yet provide enough information to determine all possible licensable IP, since companies need to know the markets for their technology. Once again, semantic processing can help. One can semantically process the public-domain patent portfolios of competitors and partners, or perform a topic-based approach, all leading to a functional index showing an overlap or a complement to the technology that you wish to license.

Eliminating Re-Design

Long-term revenue growth, market share, and competitiveness are the most compelling reasons why companies must leverage their intellectual assets. Design re-work is happening at an alarming rate of more than 65% in most companies — simply because they did not know that a problem already had been solved. Competition and market pressures point to higher productivity and more innovative product development. To truly leverage a company's knowledge, a fully automated technology is required to keep up with the information being created. This technology must be able to read, extract all relevant information, and automatically create a knowledge index based on problems and solutions. When an employee queries this knowledge base, answers are returned — not a list of documents.

The "make vs. buy" decision for product development is now an absolute step in the development process, so more and more companies continually are searching for IP that can be licensed and incorporated into their products. Semantic processing technology automatically will organize the company's knowledge into vertical knowledge bases, along with an index of functionality, so they can also assess their intellectual property and determine what can be licensed for additional revenue.

For more information, contact the author, Philip George, Vice President of Worldwide Marketing, for Invention Machine Corporation; Tel: 617-305-9250. Visit the Invention Machine web site at www.invention-machine.com.

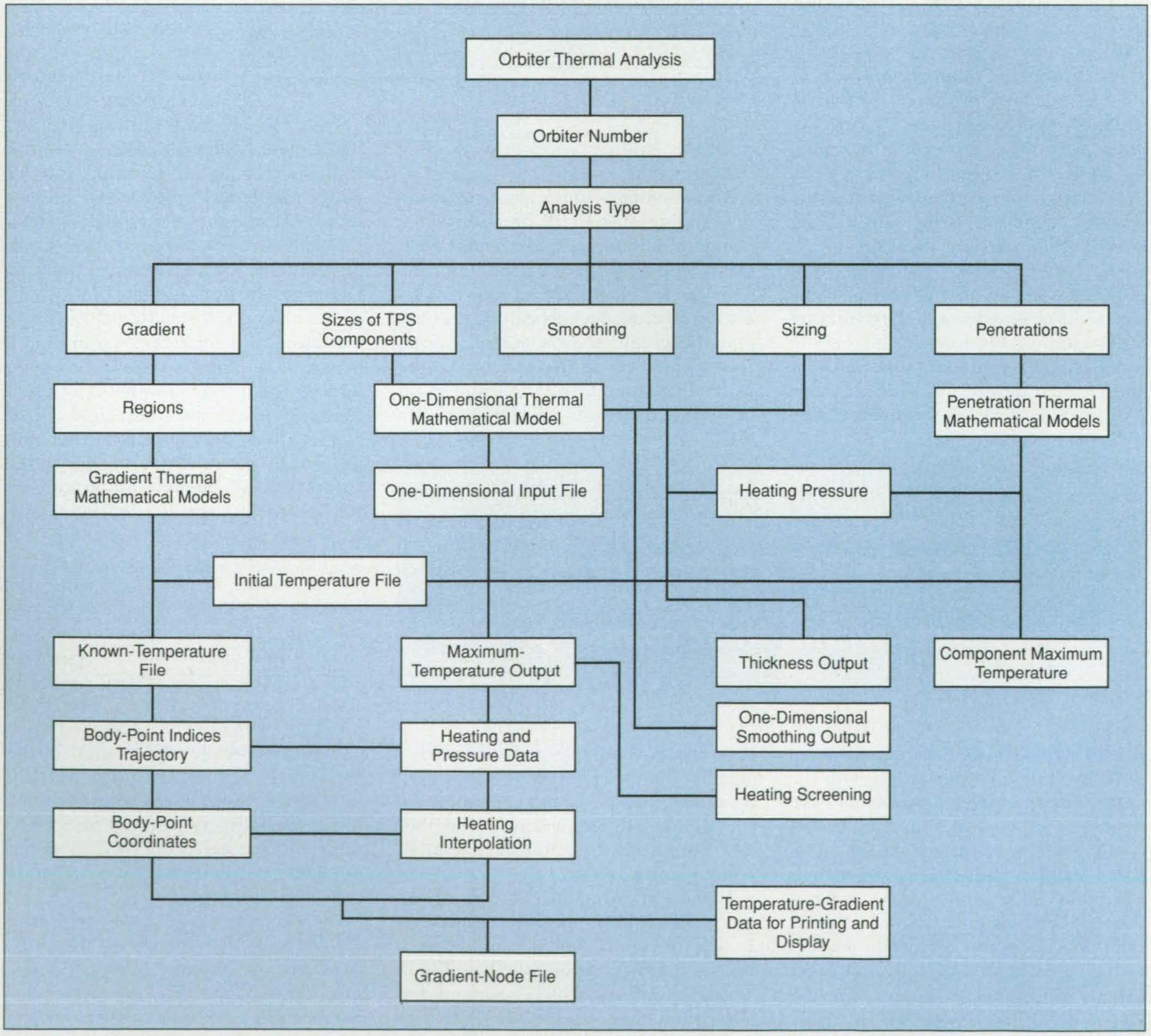
Computer Program Automates Thermal Analyses

This program reduces the costs of thermal analyses of hypersonic flight systems.

Lyndon B. Johnson Space Center, Houston, Texas

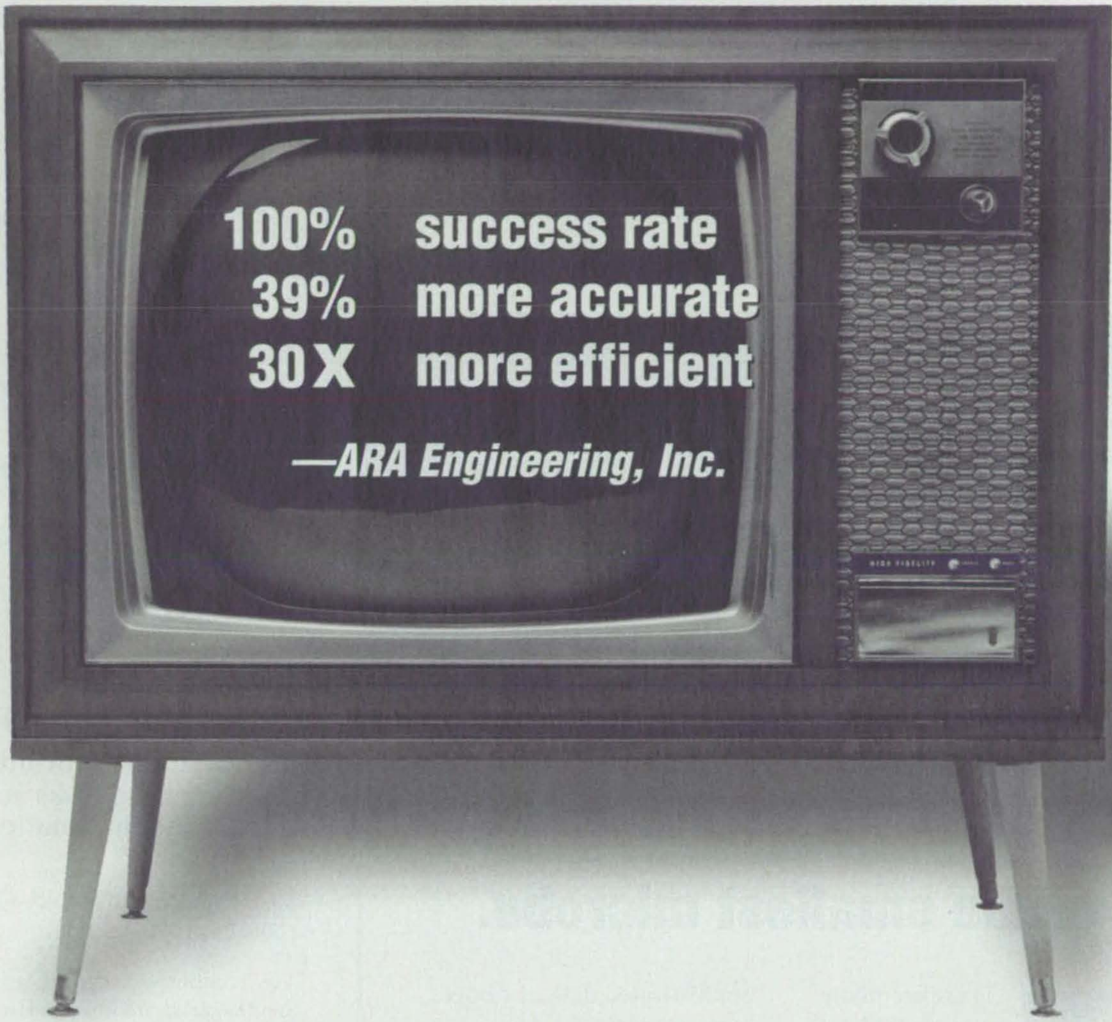
A computer program (see figure) has been developed to serve as a time- and cost-effective means of automating thermal analyses of such hypersonic flight systems as the space shuttle orbiter, the National Aerospace Plane (NASP), and the crew return vehicle (CRV). Heretofore, thermal analyses of the space shuttle orbiter have been performed manually and have, therefore, been hindered by long cycle times and the risk of human error. The present thermal-analysis automation program, which represents an advance in the state of the art, is expected to enable the sizing and analysis of thermal protection systems (TPSs) of re-entry space vehicles (RSVs) while increasing the accuracy of the analyses, reducing the amounts of labor needed to perform the analyses, and reducing the costs of the analyses.

Because the design of the TPS of a spacecraft affects the weight and thereby directly affects the operational cost and performance of the spacecraft, it is vital that adequate TPS materials be sized to minimum possible thicknesses. From a thermal perspective, the design is constrained by (1)



This **Program Flow Diagram** has been made as concise as possible to show data links among data-base files.

Considering Engineering Simulation?



(Sometimes, your decision is black and white.)

DesignSpace®

To read the complete ARA Engineering Report,
Mainstream CAE Tools:
Technical Considerations and Informative Comparisons,
visit **www.ara-eng.com/special-report.htm**

ANSYS
engineering solutions

For More Information Circle No. 534

the maximum temperature allowable on the spacecraft skin, and (2) the compositions of, and thermal gradients in, components of the TPS. Maximum thicknesses can be expected to differ, largely depending on locations on the spacecraft. To adequately define TPS thicknesses for an RSV, it is necessary to perform numerous TPS-sizing analyses. A sizing analysis is performed on a local-area basis, and engineering time is directly related to the number of sizing analyses performed. Moreover, coverage of spacecraft areas has sometimes been compromised to meet delivery schedules. Therefore, even after a sizing task has been completed, a considerable amount of engineering time is needed to verify the adequacy of faired TPS thicknesses, maximum skin temperatures, and structural thermal gradients.

With the help of the thermal-analysis automation program, these tasks can be performed easily — even if thermal analyses are required and must be repeated many times for spacecraft design. Additional capabilities of the program (e.g., those based on gradient smoothing techniques) enable preliminary airframe design to be performed to eliminate thermal-load problems in the early stages of spacecraft design. Heating-interpolation and heating-screening features can be applied to many different types and stages of thermal analysis. The trajectory difference can be evaluated easily by use of the heating-interpolation option of the program, and the heating-screening option helps to reduce the amount of work to a minimum by bypassing the thermal analysis in areas where changes in heating changes are negligible.

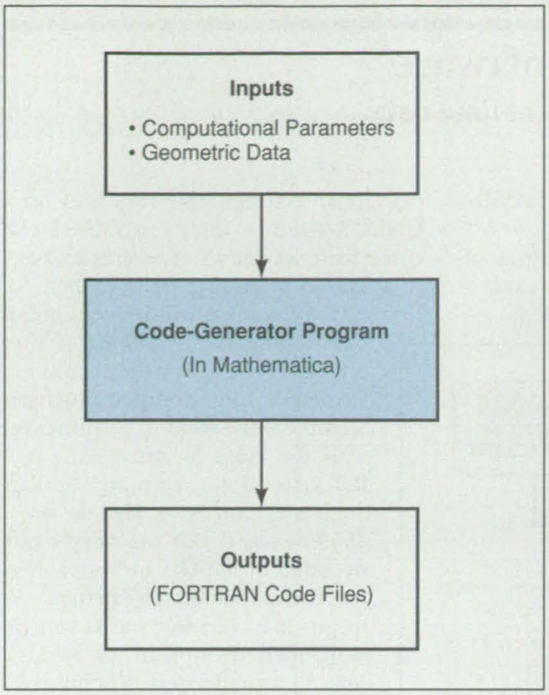
This work was done by Sun I. Hong of Boeing North American for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*
MSC-22788

Automated Generation of Acoustic-Propagation Computer Codes

Traditionally labor-intensive programming tasks are performed automatically by software.

John H. Glenn Research Center, Cleveland, Ohio

A computer program written within the *Mathematica* software system automatically generates FORTRAN computer codes that numerically simulate, with high accuracy, the acoustical physics of complex unbounded three-dimensional or bounded two-dimensional flow fields. The program is a significant contribution to the field of computational aeroacoustics (CAA), which combines the traditional disciplines of acoustics and computational fluid dynamics (CFD). The program was developed, as a first step, to accelerate and facilitate analysis of noise generated by turbofan aircraft engines. It can also be applied in many other endeavors that involve the generation, propagation, and/or scattering of electromagnetic as well as acoustic waves, or in which there are requirements to obtain highly accurate solutions of systems of hyperbolic partial differential equations that describe physical phenomena in complex environments. Prior to the development of this program, considerable programming effort was necessary even to obtain a low-accuracy com-



Once the Problem Is Specified in terms of computational parameters (e.g., numbers of grid points) and geometric data, the FORTRAN code files needed to solve the problem are generated automatically.

puter code for a typical application. The code generated automatically by this program is far more accurate and efficient.

In the original turbofan-noise application, there is a need for numerical-simulation software that has sufficient fidelity to simulate steep gradients in flow fields and that is efficient enough to run on today's computer systems. The present code-generator program was developed to satisfy this need and, more specifically, to create software that numerically solves the linearized Euler equations of flow on Cartesian grids in three-dimensional spatial domains that contain bodies with complex shapes.

The codes are based upon the recently developed Modified Expansion Solution Approximation (MESA) series of explicit finite-difference schemes. The essential idea behind the MESA schemes is to approximate the solutions of the partial differential equations instead of approximating the individual derivative terms. The MESA schemes use multidimensional spatial interpolation and the constructive procedure in the proof of the Cauchy-Kovalevsky theorem to develop a local series approximation to the solution of the system of partial differential equations in both space and time. MESA schemes provide spectrallike resolution with extraordinary efficiency and can, theoretically, offer levels of accuracy that are arbitrarily high in both space and time, without the inefficiencies of Runge-Kutta schemes. The MESA methods were originally developed in one and two dimensions with accuracy up to 11th order, but, in conjunction with the development of the present program, have been extended to three dimensions with accuracy up to 29th order in space and time.

Unfortunately, the complexity of the coding task in the original form of the MESA schemes was very high, so that in a given application, either the desired code could not be compiled or else it took an impractically long time to write the code in FORTRAN. The present code-generator program automatically codes the MESA schemes into FORTRAN. As part of the development of this program, the MESA schemes were reformulated into a very simple form, making it practical to use these schemes without the automation or, alternatively, making these schemes very powerful when the automation is used. The program provides means for treating grid-aligned solid wall boundaries in two dimensions with accuracy up to 11th order, and for treating generalized two-dimensional boundaries with accuracy up to second order. It also provides for automated parallelization of codes for execution on large-scale parallel computers.

This program is a "turnkey" code-generation software tool. Given input in the form of computational parameters plus a set of parametric curves that describe the object(s) that bound a flow field, the program automatically generates the code that simulates the acoustical physics of the flow field. The program thus relieves engineers and scientists of the traditionally labor-intensive tasks of generating computational grids, developing algorithms to solve the governing differential equations, coding the algorithms in FORTRAN, and ensuring that wall boundaries are treated correctly. By shifting these tasks to computers, the program can be expected to increase its users' productivity and capability. Additional work is required, however, to fully simulate bounded three-dimensional problems.

This work was done by Rodger W. Dyson and John W. Goodrich of **Glenn Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16970.

Rule-Based "Intelligent" Monitoring Software

This program helps to automate the analysis of batch or real-time data.

Dryden Flight Research Center, Edwards, California

Dryden Flight Research Center has developed a computer program that performs signal management for analysis in real time (SMART). This program, called "SMART," has been effectively used since 1991 in F-18, X-31, LASRE, and X-33 programs.

Figure 1 depicts the architecture of SMART. Signals are processed by executing rules (represented by Boolean expressions) that generate messages on a UNIX X-Window. Inputs to SMART can come from any or all of several sources, as discussed below:

One of the sources can be a computational simulation. SMART is very effective for use in a simulation environment, because the simulation scripts can be used in conjunction with the rules to automate pass/fail criteria for software testing. Such raw words as signals on a 1553-standard bus are very easily decoded by SMART into meaningful textual character strings. As scripts are run, test words can be controlled to indicate to SMART that a particular test is being run. SMART generates the appropriate messages for the autotesting of the simulation software. All tests are exactly repeatable, very fast, and self-analyzing.

Another source of input to SMART can be a control room for an aircraft or spacecraft mission. The use of SMART during flight testing in such programs as the X-31 and LASRE has proven to be very valuable. For flight testing, safety of flight is the primary concern, and SMART works very well because

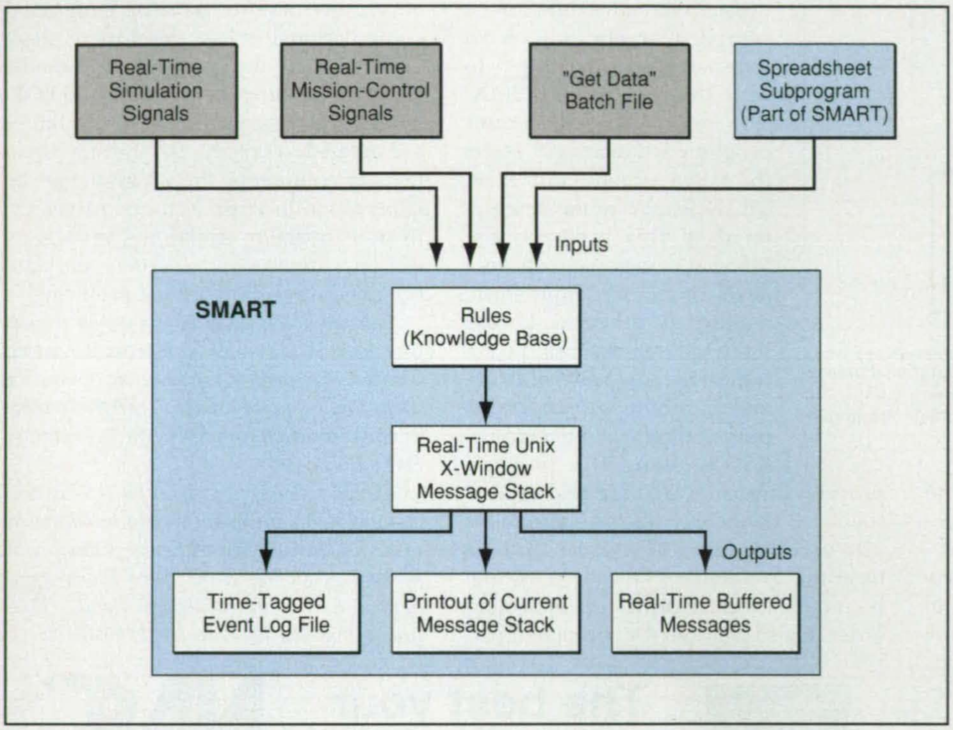


Figure 1. **SMART** can receive input from any of four sources, one of which is part of SMART itself.

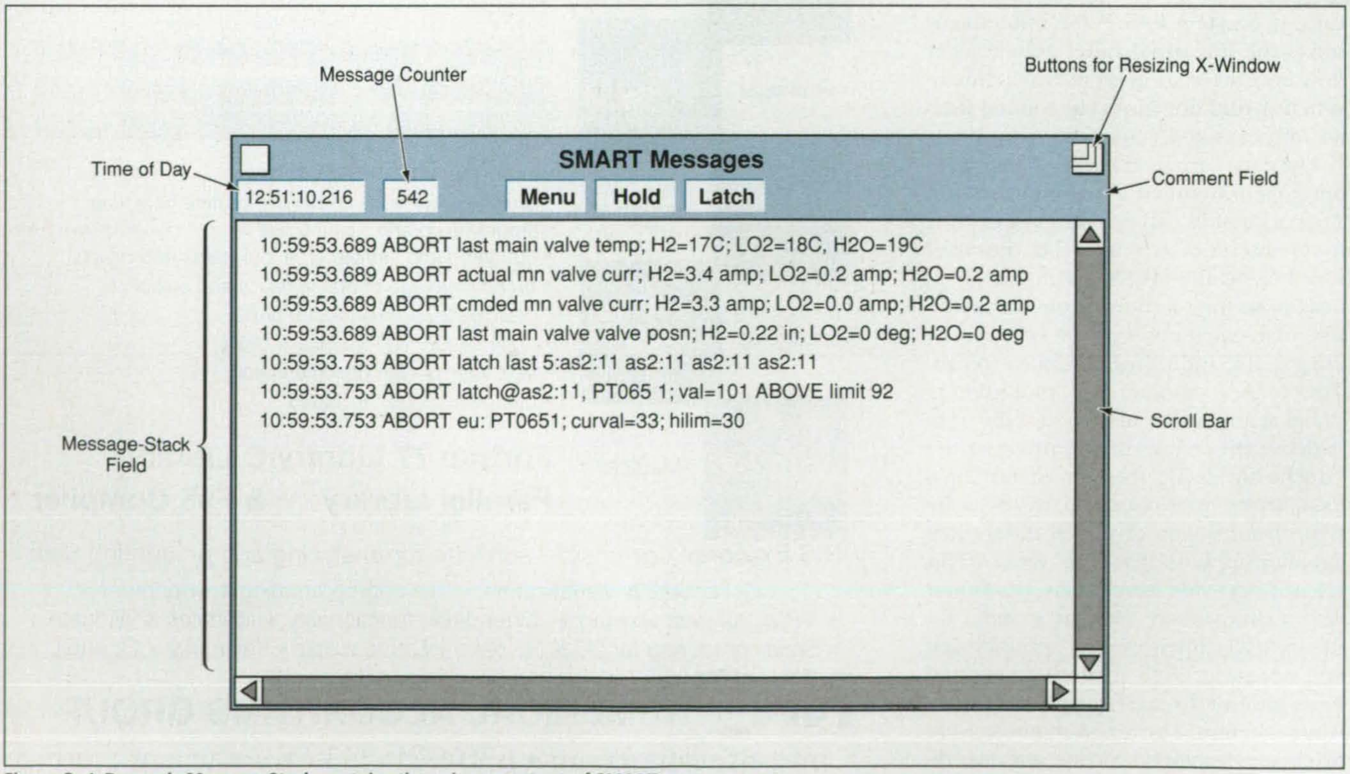


Figure 2. A **Dynamic Message Stack** contains the primary output of SMART.

health and status words are constantly being monitored. Status is not missed because when any fault is detected, a new colored (red) message is added to the top of a real-time UNIX X-Window message stack. An additional benefit is that each such message is time-tagged. Data can be analyzed easily because SMART gives event times. All faults are immediately made known to enable quick action by a flight-test team.

A third source of input is a "GetData" batch file. The capability to receive data from this source is a recent addition to SMART. SMART reads the batch file, frame by frame, at whatever rate the data come in, and generates messages according to the rules. This capability is very effective in automating the analysis of batch data. Certain events can easily be tested by the rules and messages generated. It is also very helpful in developing the rules by use of known events representative of those that it is very important to be able to detect.

A fourth source of input is a spreadsheet subprogram that is part of SMART. This subprogram is used by a rules developer to test the rules. There is an option to automatically load all the signals from an input rule source onto a spreadsheet. The tester can click a cell and type the desired data value to test the rules. The message(s) appear on the stack when the rule has been satisfied.

The primary output of SMART consists of messages put into a dynamic stack. New messages are always added to the top of the stack and as old messages are rescinded, the stack is compressed to fill in the gaps. Messages can also be color-coded to enhance the visibility of designated information. The current messages in the stack can be sent to a printer at any time by use of a print command on the SMART window.

The SMART window provides an option to save the messages in a log file on a hard disk. This option is very useful for saving time-tagged event information for testing. Certain information can be scanned out from this file by use of standard UNIX commands; this feature was found to be very useful in the LASRE program.

Another option, which was recently added to SMART, provides for triggering by a rule to generate a message and the current time and record the message and its time tag in a file. Information is continuously written into this file as long as the rule is satisfied. The message is defined by the developer. The message could be, for example, a parameter to be recorded whenever a fault flag is set. This option is meant to be used as a tool for analyzing anomalies as quickly as possible.

This work was done by Richard Larson of **Dryden Flight Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*
DRC-99-28

Comprehensive Micromechanics-Analysis Code (MAC/GMC)

Composite-material structures with complex thermomechanical load histories can be analyzed.

John H. Glenn Research Center, Cleveland, Ohio

Micromechanics Analysis Code With Generalized Method of Cells (MAC/GMC) is a comprehensive, user-friendly, efficient computer program that predicts the elastic and inelastic thermomechanical responses of continuous and discontinuous composite materials with arbitrary internal microstructures and reinforcement shapes. This program enables the efficient analysis of composite structures subjected to complex thermomechanical load histories. MAC/GMC won second place in the 1997 NASA Software of the Year competition and has been applied in industrial, government, and academic settings to such diverse composite-material structures as turbine parts, tires, and even brain tissues.

The predictive capability of MAC/GMC rests on the mathematical model known as the generalized method of cells (GMC) — a continuum-based model of micromechanics that provides closed-form expressions for the macroscopic response of a composite material in terms of the properties, sizes, shapes, and responses of the individual constituents or phases that make up the material. The viscoplastic and fatigue-life characteristics of the constituents or phases, are in turn, represented by advanced, physics-based mathematical submodels.

The GMC also incorporates expressions that relate stress and strain fields within individual constituents to macroscopically applied stresses and strains via stress-concentration factors. These expressions make possible the investigation of failure processes at the microscopic level at each step of applied-load history. The GMC also affords a capability for studying the influence of the strengths of bonds of fiber/matrix interfaces; this is an important capability because the strengths of these bonds strongly influence the progression of damage.

MAC/GMC enhances the basic capabilities of the GMC by providing a modular software framework wherein one can take advantage of any or all of the following options:

- Various thermal, mechanical (stress or strain), and thermomechanical load histories can be imposed.
- Different integration algorithms can be selected.
- Any of a variety of constitutive submodels for constituent materials can be selected from a library of such models or implemented via a subroutine defined by the user.
- Any of a variety of fiber architectures (unidirectional, laminate, and woven) can be selected from a library of representative volume elements or be defined by user.
- A postprocessing subprogram for graphical display of microscopic and macroscopic field quantities is available (MACPOST).

The most outstanding feature of MAC/GMC is its ability to accurately model composites with laminated and woven fiber architectures at minimal cost and with minimal input by the user. MAC/GMC can be executed in conjunction with standard linear and nonlinear finite-element analysis programs for cost-effective design and analysis of large structures, including fully time-dependent deformation behavior of constituents. It is also possible to model porosity, damage, interfacial regions around inclusions, and deterioration of interfaces. Multiaxial states of stress or strain can be applied and predicted accurately, regardless of the orientations of fibers.

One advantage of the use of constitutive submodels is that any type of simple or combined loading (e.g., multiaxial stress) can be applied, irrespective of symmetry or asymmetry, and without resorting to different boundary-condition application strategies. An analytical macro elastic-thermo-inelastic constitutive law offers

For More Information Circle No. 529

the advantage of reducing the amount of memory needed in a finite-element structural-analysis code; it also enables coupling of optimization algorithms with the solution for automated tailoring of the material and structure under analysis. Furthermore, this formulation has been shown to predict macroscopic behavior accurately, given only a few subcells within a repeating cell.

This work was done by Steven M. Arnold of **Glenn Research Center**, *Brett A. Bednarcyk of Ohio Aerospace Institute, and Thomas E. Wilt and Daniel E. Trowbridge of the University of Akron. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16870.

Software for Analyzing Forth Programs

Various parts of code can be categorized and quantified in selectable ways.

Marshall Space Flight Center, Alabama

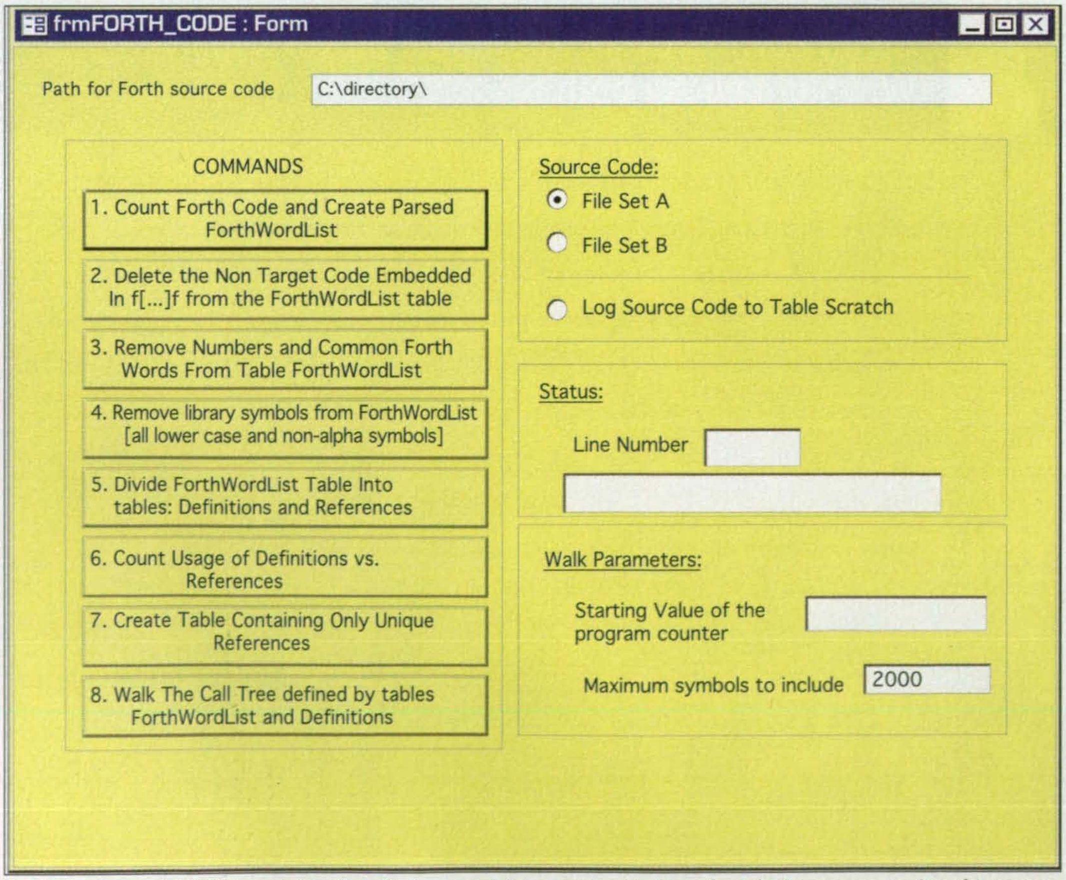
Forth Source Code Analysis Tool Set (FSCATS) is a computer program that provides a wide range of capabilities for documenting, analyzing, and reverse-engineering computer programs written in the Forth programming language. FSCATS also aids in the management of software, estimating costs of software, and development of metrics for characterizing software.

The functions performed by FSCATS include the following:

- Categorizing lines of code and counting the lines in each category;
- Producing cross-references for all words, constants, and variables;
- Producing cross-references for all definitions;
- Identifying unused and multiplicate definitions;
- Identifying unused and undefined Forth words;
- Identifying development system code, missing library definitions, and missing compiler definitions; and
- Listing a call tree at selectable levels of detail
  - — All symbols (full structure)
  - — Selected categories of symbols (partial structure)
  - — Only application-code-type symbols (classical structure chart).

The aforementioned functions are enhanced by presenting all results in tables in the Microsoft Access software environment. The availability of results in tabular form provides the user with extraordinary flexibility in tailoring FSCATS to produce a wide range of sorted and filtered views. By use of the report capabilities of Microsoft Access, tables of summary information can readily be printed as needed.

The figure depicts an interactive display, denoted the "main form," used to control the operation of FSCATS. The main form contains eight command buttons for processing a source code and obtaining results. Command buttons 2, 3, and 4 enable the user to view the source code at the three levels of detail mentioned above. The structure-chart level obtains when all filters are used and the remaining code set consists of application-level Forth words.



The **Main Form** of FSCATS is an interactive display containing command buttons for selecting among options for processing code and obtaining the results of processing.

FSCATS was written for execution on an IBM-compatible computer containing a '486 or higher processor with at least 10MB of free hard-disk space and 16MB of random-access memory. The Windows 95 or Windows NT operating system, the Office 95 software, and Microsoft Access (version 7.0 or later) are needed to run FSCATS.

This work was done by Michael Neighbors of Micro Craft Inc. for **Marshall Space Flight Center**. *For further information, please contact the company by e-mail at theneighbors@zebra.net. MFS-31255*

Special Coverage: Design & Analysis Software

MICROCADAM, Burbank, CA, offers Helix2000, the latest version of Helix Design System™ **design software.** The program also features Helix Craftsman, a topological modeling toolkit for local shape deformation, design change, and accurate model healing. Helix2000 incorporates dual-hybrid modeling that integrates surfaces with solids, combining both parametric and topological design changes.

Other improvements include a new dragging axis for easier positioning by intelligently snapping parts into place. Users can embed mating condition intelligence into parts prior to assembly, so they "understand" how they should fit together. The software also allows creation of annotation symbols for tolerances and surface finish. It can convert 2D AutoCAD® drawings into 3D solids.

For More Information Circle No. 711

FilterShop™ 3.0 **analog/digital filter design and analysis software** from LinearX Systems, Tualatin, OR, features a proprietary circuit simulation engine, components for mixed analog/digital design, and a target generation system. The proprietary AC circuit simulator features full graphical schematic entry and editing.

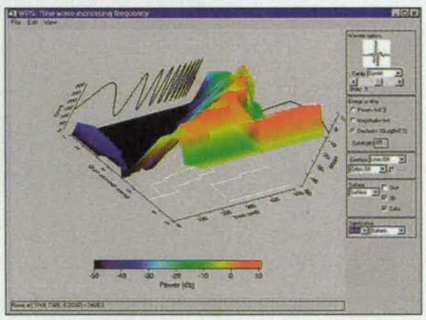
Other enhancements include circuit synthesis with more than 500 predefined circuit templates and built-in design equations; mixed signal circuit components including FDNRs, Z-impedance, and potentiometers; and analog filter design wizards for any Allpole or Elliptic filter. Processing features for Monte Carlo, thermal, noise, and potentiometer analysis are included.

For More Information Circle No. 712

GE Fanuc Automation, Charlottesville, VA, has introduced fxManager Automation Management System Version 1.20 **graphical automation analysis software** with an HTML interface that enables users to click on customized graphical representations of their locations in a facility.

Providing management and analysis of automation systems software, the program is a client/server system with version control, audit trail, security, and scheduling capabilities. The software supplies the analysis and reporting tools necessary to meet validation or quality system requirements, and optimizes engineering practices throughout system life cycles.

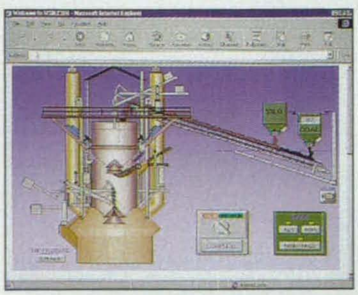
For More Information Circle No. 714



IDL Wavelet Toolkit **data analysis software** from Research Systems, Boulder, CO, is an add-on to the IDL (Interactive Data Language) visualization and application software. The toolkit enables IDL users to analyze, filter, and compress large amounts of data for storage or Internet posting. Users are able to manage projects, import data, define wavelets, and visualize the results from a single graphical user interface.

Other features include a discrete wavelet transform, 3D wavelet power spectrum visualizer that plots wavelet power as a 3D surface, and the ability to import data from ASCII, JPEG, GIF, TIFF, binary, and .wav audio file formats. The software enables users to filer out frequencies and white noise that show up in data.

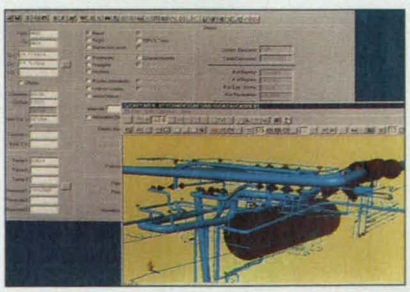
For More Information Circle No. 710



InduSoft, Hilton Head, SC, offers InduSoft Web Studio **data analysis software** that displays information from any control or data acquisition system that conforms to Microsoft's DNA architecture. It works on any standalone Windows PC, or on a client/server system that uses thin client workstations. The software allows the use of popular Web browsers such as Netscape or Windows Explorer to display real-time, dynamic and animated graphic screens, trends, alarms, and reports.

The program exports data using XML format, and includes an object-oriented database based on the Microsoft SQL environment for storing and retrieving information. It also includes math functions, report generation, archiving, batch recipes, and interfaces for PLCs, remote I/O, serial links, and TCP/IP networking. The software also provides automatic error checking.

For More Information Circle No. 713



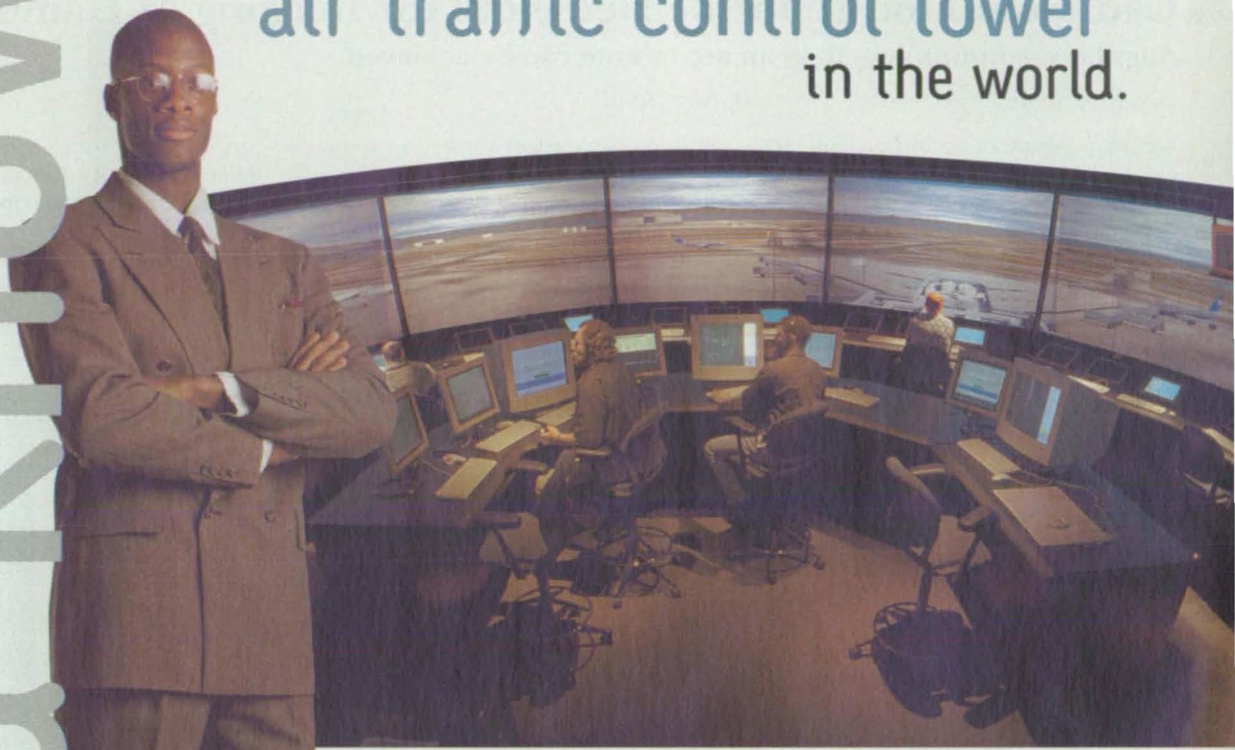
COADE, Houston, TX, has introduced CAESAR II Version 4.20 **pipe stress design and analysis software** for Windows 95/98/NT. New features include hydrodynamic load analysis, linear and power law current profiles, and a wave scratchpad to view the recommended theory graphically or to plot the specified wave's particle data. It also includes the Airy, Stokes 5th, and Stream Function wave theories.

The package includes pipe stress analysis; API, NEMA, WRC, and AISC component evaluation; component databases; automatic spring sizing; structural steel modeling; automatic underground pipe modeling; material database with allowable stress data; fiberglass piping capabilities; and a 3D graphics library. A materials library and an online applications guide also are included.

For More Information Circle No. 715

Did you know?

SGI powers the only full-scale 360-degree virtual reality air traffic control tower in the world.



SGI and NASA Ames Research Center have created the air traffic control tower of the future—today.

NASA FutureFlight Central provides the ability to virtually test and prevent potential air and runway traffic problems. The possibilities of this technology are limitless. It could enable control towers to collaborate in real time with international airports, visually predict and therefore prevent commercial flight delays or accidents, and even manage interplanetary traffic control some day.

By using the Silicon Graphics® Onyx2® visual workstation to process complex 3D graphics, imaging, video, and satellite data in real time, the system can portray any airport in the world in realistic 360-degree high-resolution images.

Win a Silicon Graphics® 1600SW flat panel display.

Visit our Web site to find out more how SGI Federal can help you see the future. While you're there, enter to win one of our award-winning flat panel displays. Complete contest rules are located at *www.sgifederal.com*.

www.sgifederal.com
ffc.arc.nasa.gov

For More Information Circle No. 560

sgi federal™
an SGI company

Cadmium Zinc Telluride Detectors for Imaging of Gamma Rays

Angular resolution less than an arc minute can be achieved.

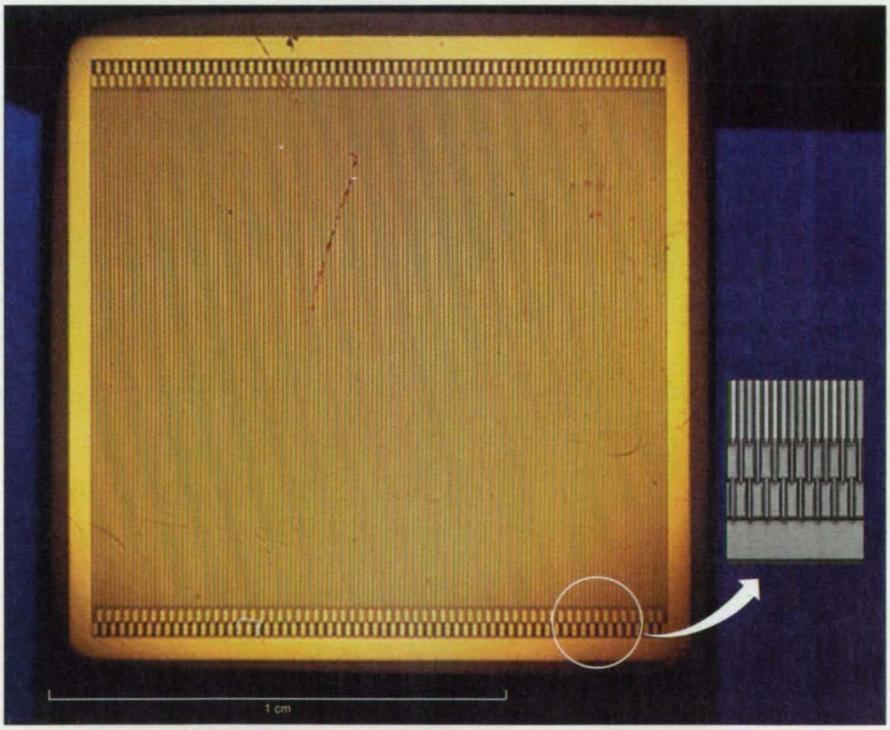
Goddard Space Flight Center, Greenbelt, Maryland

Planar arrays of cadmium zinc telluride photodetectors with readout electronic circuitry have been developed for use as hard-x-ray and γ-ray image sensors. When a coded, x-and-γ-ray-opaque aperture mask is positioned in front of such a sensor, the resulting assembly is an instrument that can be used to observe hard-x-ray and γ-ray sources. In operation, the spatial pattern of x and γ rays impinging on the sensor is deconvolved from the aperture pattern to obtain an image of the source. With suitable choice of the sensor pixel pitch, coded aperture pattern, and distance of the aperture in front of the detector array, it should be possible to image radiation sources at angular resolutions of 30 arc seconds and finer. In the original intended application, the instrument will be operated in outer space to measure precisely the directions to distant sources of hard-x-ray and γ-ray bursts that are of cosmological interest. The instrument can also be used to image hard-x-ray and γ-ray-sources in a terrestrial laboratory setting; indeed, a prototype of the instrument has been demonstrated in such a setting.

Prototype sensors containing 2 × 2 and 6 × 6 arrays of detector modules made from $Cd_{0.9}Zn_{0.1}Te$ have been constructed (see figure). The dimensions of a module are 15 by 15 by 2 mm. Each face of a module is patterned with 127 metal strips, each 50 µm wide, at a pitch of 100 µm. The strip pattern is surrounded by a 450-µm guard ring. The metal strips divide the module into, and serve as electrical contacts for, a corresponding pattern of strip detectors. The strips on the front and back faces are made orthogonal to each other to establish a square pixel grid with a pitch of 100 µm.

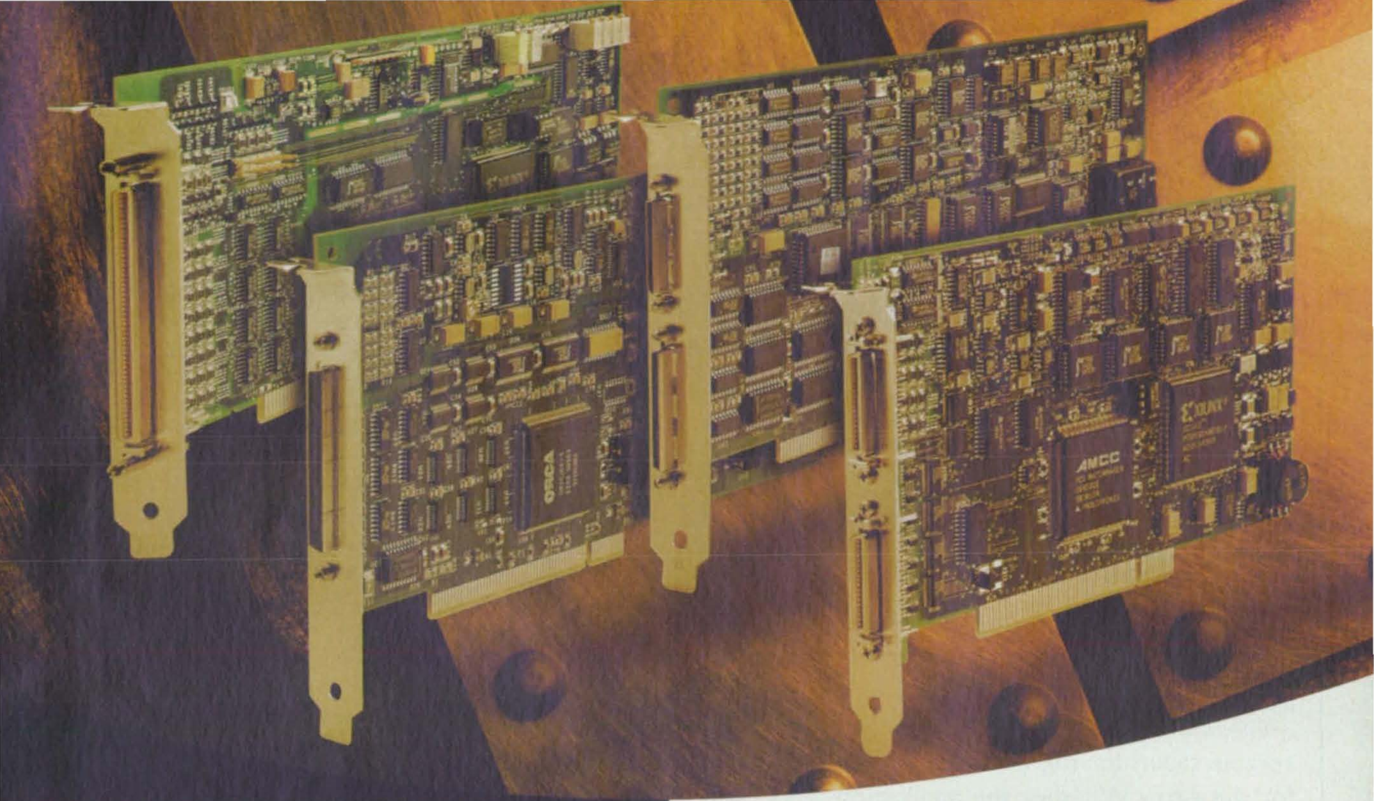
The row and column metal strips that are collinear with each other in the various modules are electrically tied together with wire bonds to make long strips that span the entire array of modules, thereby defining a pixel coordinate grid over the whole array. The row and column strips are biased via monolithic resistors formed in voltage-divider configurations along two orthogonal edges of the array. For readout, the strips are ac-coupled, via 1,000-pF capacitors, to high-density application-specific integrated circuits.

In operation, the $Cd_{0.9}Zn_{0.1}Te$ material absorbs photons with energies between 10 and 150 keV. The electrons and holes generated in the absorption of photons drift to the anode and cathode strips, respectively, where they are collected. The charges collected on orthogonal anode and cathode strips indicate the magnitudes and positions of photon-impingement events in the detector plane. Because the cloud of drifting charges induced by each photon has a finite size and can diffuse outward as the carriers drift, charge is typically induced on three adjacent strips at 100-µm pitch. The position of impingement is determined from the average of the strip numbers weighted by the charges induced on the affected strips. In addition, the charges on affected adjacent strips must be summed for accuracy in determining the photon energy. For even greater accuracy, it is necessary to sum the signals from anode strips because the charges collected on cathode strips are reduced because of the poor hole-transport properties of $Cd_{0.9}Zn_{0.1}Te$.



Detector Modules like this one are arranged in a square array to form a sensor for imaging of hard x rays and γ rays. A pixel pitch of 100 µm in two dimensions is defined by orthogonal arrays of detector strips on the upper and lower faces of each module.

Using 60-keV γ rays from a ^{241}Am source, a 2 × 2 prototype sensor was tested in conjunction with a 40-µm-thick gold aperture mask patterned in a 100-µm-pitch square grid supported by a 1-mm-thick beryllium substrate. The aperture mask was placed 32 mm in front of the sensor (in the fully developed instrument, the mask would be placed 800 mm in front of the sensor). The results of the test revealed that the prototype instrument was capable of an angular resolution of about 30 arc seconds. The results give confidence in computer simulations that predict that the fully developed instrument will be



able to locate about 90 γ-ray bursts per year to an accuracy of ±3 arc seconds, and to produce an all-sky survey with a resolution of 30 arc seconds.

This work was done by L. Barbier, N. Gehrels, B. Teegarden, A. M. Parsons, L. M. Bartlett, P. K. Shu, and J. Tueller of **Goddard Space Flight Center**; *C. M. Stahle of Orbital Sciences Corp.; Z. Q. Shi, K. Hu, and S. J. Snodgrass of Hughes STX Corp.; D. M. Palmer, S. D. Barthelmy, and J. Krizmanic of Universities Space Research Association; S. J. Lehtonen and K. J. Mach of Johns Hopkins University Applied Physics Laboratory; P. Kurczynski of the University of Maryland; E. Fenimore of Los Alamos National Laboratory; and D. C. Mancini of Argonne National Laboratories. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category. GSC-14044*

Inexpensive Packaged Subharmonic Down-Converter MMICs

MMICs like these could be used in microwave digital communication receivers.

John H. Glenn Research Center, Cleveland, Ohio

Two packaged monolithic microwave integrated-circuit (MMIC) mixers have been designed to operate as subharmonically pumped frequency down-converters in receivers of satellite- or ground-based digital communication systems. One operates a radio frequency (RF) between 17 and 20 GHz, the other at an RF between 22 and 32 GHz (see Figure 1). These MMICs are of a type described in "MMIC Converters for K- and Ka-Band Communications" (LEW-16752), *NASA Tech Briefs*, Vol. 23, No. 7 (July 1999), page 59. The approach taken in developing this type of MMIC is one of minimizing costs by relying on well established design practices and mature, commercially available processes for fabrication of MMIC chips.

Both mixers incorporate onboard local-oscillator (LO) amplifiers to reduce the required LO drive levels. The 22–32-GHz mixer also incorporates an output [intermediate-frequency (IF)] amplifier. To reduce the sizes and thus

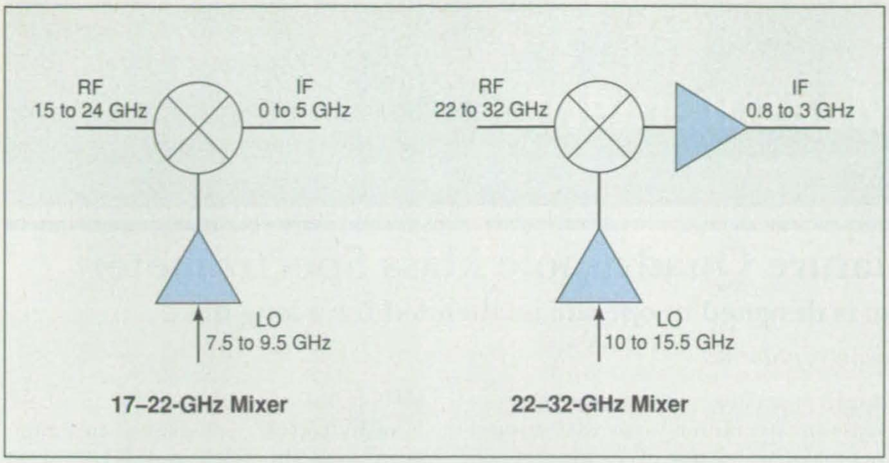


Figure 1. The **Two Mixer Circuits,** shown here in simplified schematic form, feature single-ended configurations that minimize size. Inexpensive filters (not shown here) provide the needed isolation among the different frequencies.

the costs of the mixer chips, both mixers incorporate lumped circuit elements for matching of impedances (in contradistinction to the transmission-line impedance-matching elements customarily used for microwaves).

The specific practices and processes chosen for design and fabrication of the 17–20-GHz MMIC are those of GaAs metal/semiconductor field-effect transistors (MESFETs) with 0.5-μm design rules, while those of electron-acceptor-doped high-electron-mobility transistors (p-HEMTs) with 0.25-μm design rules were chosen for the 22–32-GHz MMIC. Figure 2 depicts the two MMIC chips. Both MMIC chips are integrated into ball-grid-array (BGA) packages, which are leadless ceramic interconnection substrates with tungsten/copper vias; the MMICs are inserted in these packages in surface-mount configurations and bonded in place by use of arrays of noncollapsing, hard balls made of a copper/silver eutectic alloy.

In tests, the 17–20-GHz down-converter was found to perform well at RFs from 15 to 24 GHz, LO frequencies of 7 to 10.5 GHz, and IFs from 0 to 5 GHz. The 22–32-GHz down-converter was found to perform well over the RF range from 22 to 32 GHz in tests in which the LO frequency was swept, along with the RF, to maintain an IF of 2 GHz.

This work was done by Paul Blount of Hittite Microwave Corp. for **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16805.

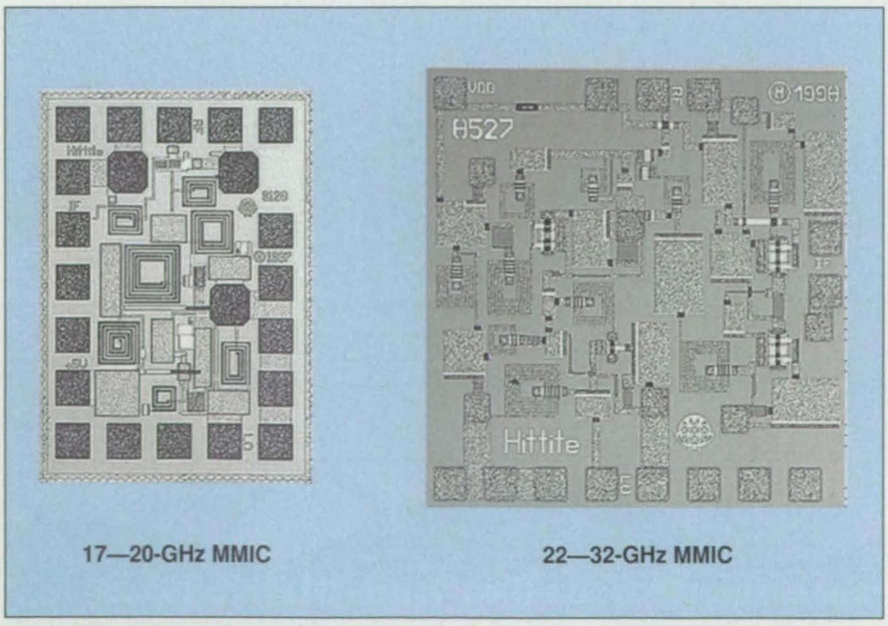


Figure 2. The **Two MMIC Chips** are compact: The 17–20-GHz chip has an area of 0.7 mm^2; the 22–32-GHz chip has an area of 1.25 mm^2.

Test and Measurement

Power Supply for Miniature Quadrupole Mass Spectrometer

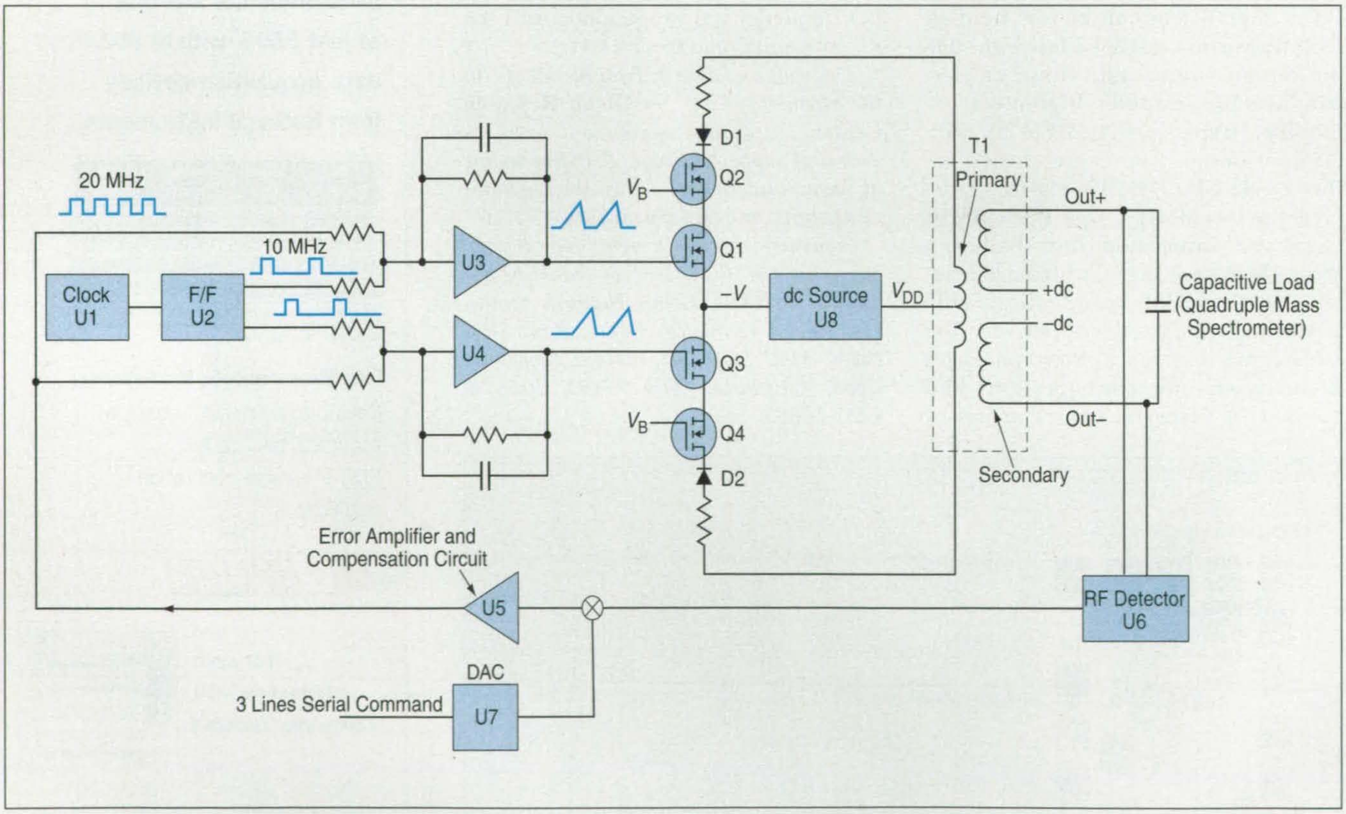
This lightweight, low-power system is designed to operate unattended for a long time.

NASA's Jet Propulsion Laboratory, Pasadena, California

A lightweight, low-power-consumption power supply has been developed to generate a combination of radio-frequency (RF) and dc voltages needed for the operation of a miniature quadrupole mass spectrometer that could operate unattended in the field for a long time, possibly using a battery as an energy source. More specifically, the circuit is designed to supply large, variable, frequency- and amplitude-stable RF voltages, variously floating or superimposed on positive or negative dc voltages, for application to primarily capacitive mass-spectrometer loads with capacitances of the order of 50 pF.

The figure is a simplified block diagram of an ac section of the power supply. This section puts out a signal with a frequency of 10 MHz, though in general, the frequency could be extended to as much as 100 MHz. The basic high-frequency clock signal for this section is generated by oscillator U1 at a frequency of 20 MHz. Flip-flop (FF) U2 divides the frequency by two, producing two 10-MHz pulse trains that differ in phase by a half cycle. Integrator and summing amplifiers U3 and U4 convert the 10-MHz clock pulses to sawtooth waveforms.

Q1 is a high-speed metal oxide/semiconductor field-effect transistor (MOSFET) that turns on when the sawtooth waveform applied to its gate goes beyond its threshold voltage. The conduction angle and the conducted current can be increased by increasing the sawtooth voltage. Q3 operates similarly to Q1, but a half



This **Circuit Generates RF and dc Voltages** for application to predominantly capacitive loads in a miniature quadrupole mass spectrometer.

cycle out of phase with Q1. Q1 and Q3 drive the primary windings of air-core transformer T1.

The air-core transformer design is chosen over a ferromagnetic-core design to obtain a desired combination of low weight, low loss, and low capacitance, and the ability to generate a large RF output voltage. The primary/secondary flux coupling, and thus the gain, can be adjusted in the design by choice of the winding ratio or can be changed by mechanical adjustment of the distance or overlap between the primary and secondary windings. These adjustments are inextricably coupled with the adjustment of the inductance of T1 to resonate with the capacitance of the affected portion of the quadrupole mass spectrometer.

U6 is an RF-detector circuit that generates a voltage proportional to the amplitude of the RF output signal. U5 is an error amplifier and compensation circuit, the output of which is a control signal proportional to the difference between (1) the actual RF output amplitude and (2) the commanded RF output amplitude as represented by the output of digital-to-analog converter U7. This control loop maintains a stable RF output amplitude during long-term operation.

One basic problem in the design of power-supply circuits like this one is to obtain a large dynamic range for the output signal. At a low level, the drive signal is coupled through the gate-to-drain capacitances of the MOSFETs, giving rise to an output signal much greater than the desired minimum. To counteract this effect and thereby extend the lower limit of the dynamic range of the mass spectrometer to below one atomic mass unit, a diode (D1) and a cascode stage (Q2 with bias V_B), is incorporated into the branch that contains Q1, and a similar combination (D2 and Q4) is added to the branch that contains Q3.

Another problem is obtaining sufficient sawtooth amplitude to drive the MOSFETs at the highest desired power levels; the peak amplitude (3 to 4 V) generated by currently available operational amplifiers is too low. In the present circuit, the return of the main dc source (U8) for driving the primary of T1 is referred to a negative voltage ($-V$). Thus, the apparent peak of the sawtooth signal applied to the MOSFET is increased by V, making it possible to reach correspondingly higher power levels.

This work was done by Ara Chutjian, Dean Aalami, Murray Darrach, and Otto Orient of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Test and Measurement category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Technology Reporting Office
JPL
Mail Stop 122-116
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

Refer to NPO-20493, volume and number of this NASA Tech Briefs *issue, and the page number.*

Make your move to COSMOS/™ today!

Program Predicts Creep Lives of Ceramic Components

This software blends theoretical and empirical knowledge to predict creep rupture.

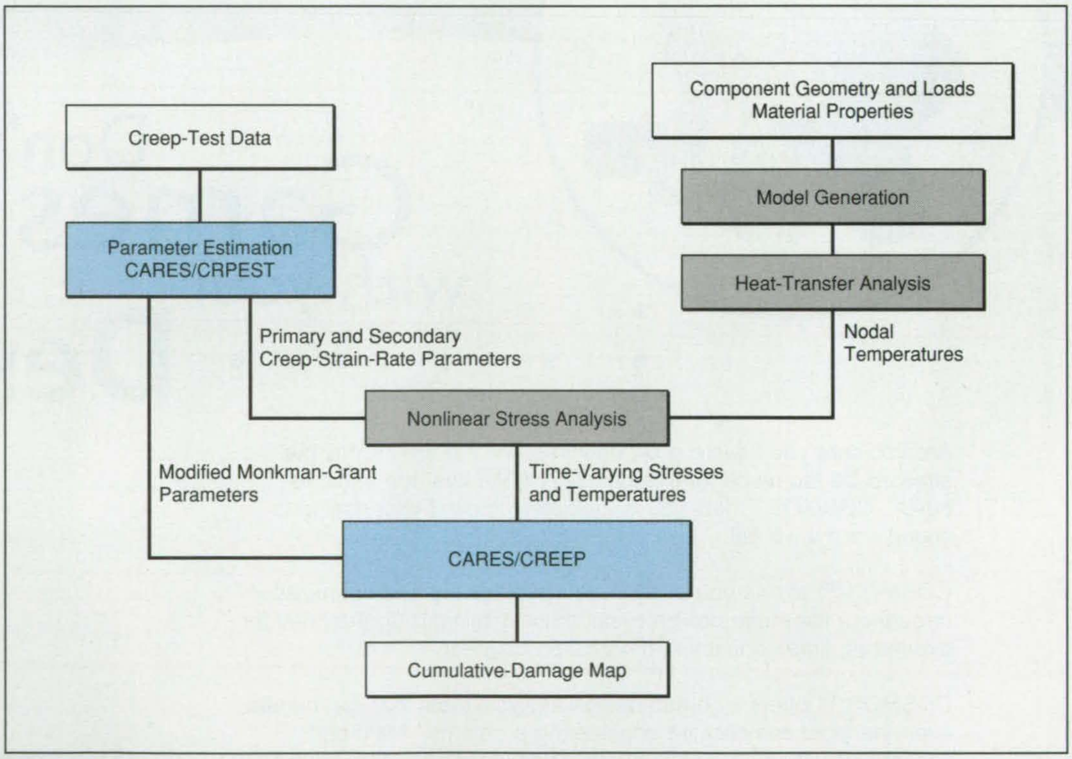
John H. Glenn Research Center, Cleveland, Ohio

Ceramics Analysis and Reliability Evaluation of Structures/Creep (CARES/CREEP) is a computer program that predicts the creep lives of ceramic structural components. [CARES/CREEP should not be confused with the related program CARES/LIFE, which was described in "Program for Evaluation of Reliability of Ceramic Parts," *NASA Tech Briefs*, Vol. 20, No. 3 (March 1996), page 28.] CARES/CREEP is integrated with the commercially available ANSYS finite-element code and is intended to be used, in conjunction with ANSYS, to design ceramic structural components of advanced turbine engines.

The need to predict creep lives for hot engine structures arises from the expected service conditions and durability requirements. The high-temperature properties of ceramic structural components make them attractive for use in advanced turbine engines, the design operational lives of which can exceed 10,000 hours. In order to enable ceramic components to last such long times, one must subject them to relatively low stresses. The combination of high temperatures and low stresses typically causes failures of monolithic ceramic components to occur in the creep regime.

CARES/CREEP utilizes the finite-element heat-transfer and nonlinear-stress-analysis capabilities of ANSYS to obtain temperature and stress distributions in a ceramic component. CARES/CREEP takes account of time-varying creep-strain distributions (stress relaxation). The creep life of a component is discretized into short time steps, during each of which the stress and strain distributions are assumed constant. The increment of damage at each time step is calculated on the basis of a modified Monkman-Grant creep-rupture criterion. The cumulative damage is subsequently calculated as time elapses in a manner similar to that of Miner's rule for cyclic fatigue loading. Failure is assumed to occur when the normalized cumulative damage at any point in the component reaches unity. The elapsed time to occurrence of such a failure is considered to be the creep rupture life of the component.

CARES/CREEP is run as a postprocessor of ANSYS output. The program (see figure) consists of two modules: The first module is a parameter-estimation subprogram that computes (1) the primary creep parameters based on the time hardening rule (a widely accepted constitutive equation that closely approximates empirical data on creep as a function of stress, temperature, and time), (2) the steady-state parameters based on the Norton equation, and (3) the creep-rupture parameters based on the modified Monkman-Grant criterion. The second module calculates the cumulative damage and thus the creep-rupture life of the component in question. Among the outputs of the program is a cumulative-damage plot for graphical rendering of critical regions of the component.



This **Block Diagram** depicts the flow of information in a creep analysis of a monolithic ceramic component by use of CARES/CREEP.

This work was done by John P. Gyekenyesi of **Glenn Research Center**, *Lynn M. Powers of Cleveland State University, and Osama M. Jadaan of the University of Wisconsin. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Software category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16917.

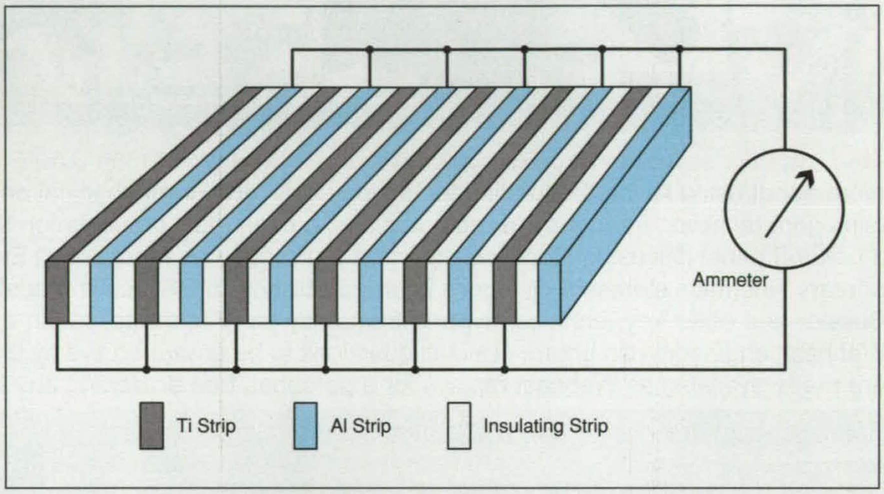
Physical Sciences

Vapor Corrosion Cell

This device detects corrosive gases that form during combustion and other processes.

Lyndon B. Johnson Space Center, Houston, Texas

The presence of corrosives in the Earth's atmosphere is of global concern. From acid rains that are destroying forests and disfiguring monuments like the Parthenon and the pyramids, to atmospheric pollutants that produce smog and induce emphysema in a significant number of people, the introduction of corrosives and other pollutants into the atmosphere is a critical and continuing environmental issue. No less critical to the space program is the presence of corrosives (reactive gases and water vapor) that are generated as byproducts of the launch process. The vapor corrosion cell developed for Johnson Space Center can be used to detect corrosives early in the formation



The **Vapor Corrosion Cell** is an electrochemical cell that generates a measurable current in the presence of airborne corrosive substances.

process; that is, before significant quantities are vented into the atmosphere.

The development of the vapor corrosion cell went well beyond the original intent by leading to procedures that, if followed, are expected to help clean up the environment by severely limiting the harmful effects of such corrosive gases as nitrogen dioxide, hydrogen chloride, sulfur dioxide, and acidic aerosols. The availability of the vapor corrosion cell is also expected to encourage the testing and development of alloys that will prove resistant to corrosion. Moreover, by detecting corrosives at an early stage, the vapor corrosion cell can help to reduce costs, save time, and increase safety margins. This device is expected to be vital not only in the space program but also in the military, in activities and institutions that focus on the environment, in the aviation industry, and in any other industries, institutions, and activities in which there are risks that chemical processes will produce corrosive byproducts. Initial testing has shown that the vapor corrosion cell is highly sensitive to corrosives and that the cell can be reversed and rejuvenated to enable multiple measurements. Hence, the vapor corrosion cell is a significant step towards redressing the imbalance caused by the release of corrosives into the atmosphere through chemical processes.

In an atmosphere filled with chemically reactive gases and water vapor, such as are present at liftoff on a launch pad, the vapor corrosion cell is the only device capable of gauging the atmospheric corrosion potential. The cell (see figure) contains strips of alternating, dissimilar, electrically conductive materials — elemental metals or alloys — separated by thin strips of an electrically nonconductive material. In the example of the figure, the dissimilar electrically conductive materials are aluminum and titanium. This device is responsive to (1) the pressures of reactive vapors and the concentration of water vapor in the atmosphere; (2) the nature and surface areas of the two dissimilar conductors; (3) the nature and thickness of the electrically nonconductive separator; and (4) the ambient temperature. By controlling all but one of these parameters, one can operate the vapor corrosion cell in such a manner as to use it to measure the remaining parameters.

All the strips of each of the two electrically conductive materials are electrically connected in parallel. An electrochemical potential develops between the two dissimilar conductor strips when their edges are exposed to an at-

mosphere that contains water vapor and a reactive vapor or gas. If the electric circuit is closed, the current flows. The current can be measured as an indicator of electrochemical activity and corrosion on the exposed surfaces. The measured current can be taken to indicate presence of hazardous gases, such as nitrogen dioxide, hydrogen chloride, or sulfur dioxide, all of which, even in minute quantities, are corrosives capable of eating away at metals or polluting the atmosphere.

The vapor corrosion cell measures air pollutants and the corrosive effects of such pollutants on metal structures. It enables the development of criteria, based on resistance to corrosion, for better selection of materials. This device can be employed around launch platforms to perform real-time corrosion measurements and to provide data for predicting the life expectancies of metals exposed to corrosives. The device can also be used on aircraft platforms or ships to monitor the environment. At present, this device is used to address a major environmental concern — that of measuring corrosion caused by acid gases generated as byproducts of industrial chemical processes. This device thus becomes a new and valuable ally in the early detection of corrosives.

This work was done by Dennis D. Davis and Anna H. DeArmond of AlliedSignal, Inc., for **Johnson Space Center.**

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-22871.

Controlling Crystal-Growth Habit in Directional Freezing

Lyndon B. Johnson Space Center, Houston, Texas

A method of controlling the crystal-growth habit in directional freezing has been devised. A substance can be purified by directional-freeze crystallization, wherein (1) the liquid phase of the substance is partially frozen, causing impurities to become preferentially concentrated in the remaining unfrozen liquid (they are more soluble in the liquid than in the solid), (2) the unfrozen liquid containing a large part of the impurities is extracted, and (3) the remaining crystalline phase is melted. The present method is directed toward reducing the entrapment of liquid within the crystalline structure, thus enhancing separation efficiency. The method is based on the observation that uniformity in heat-transfer conditions is of the utmost importance in forming uniform crystals in which little liquid is entrapped.

This work was done by William M. Conlon of Polar Spring Corp. for **Johnson Space Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Polar Spring Corp.
3501 Edison Way
Menlo Park, CA 94025

Refer to MSC-22518, volume and number of this NASA Tech Briefs *issue, and the page number.*

Special Coverage: Computers & Peripherals

RS-232-to-Infrared Transceiver

This unit can readily be reprogrammed for a different baud rate or protocol.

Marshall Space Flight Center, Alabama

A transceiver has been developed to serve as a data-communication link between (1) the RS-232-standard serial communication port of a personal computer (PC) running the Windows 95 or Windows NT operating system and (2) a remote infrared transceiver that is capable of operation at a baud rate ≤4 MHz. The PC-to-transceiver communication is 115.2 kilobits per second, while the infrared communication is at 4 megabits per second.

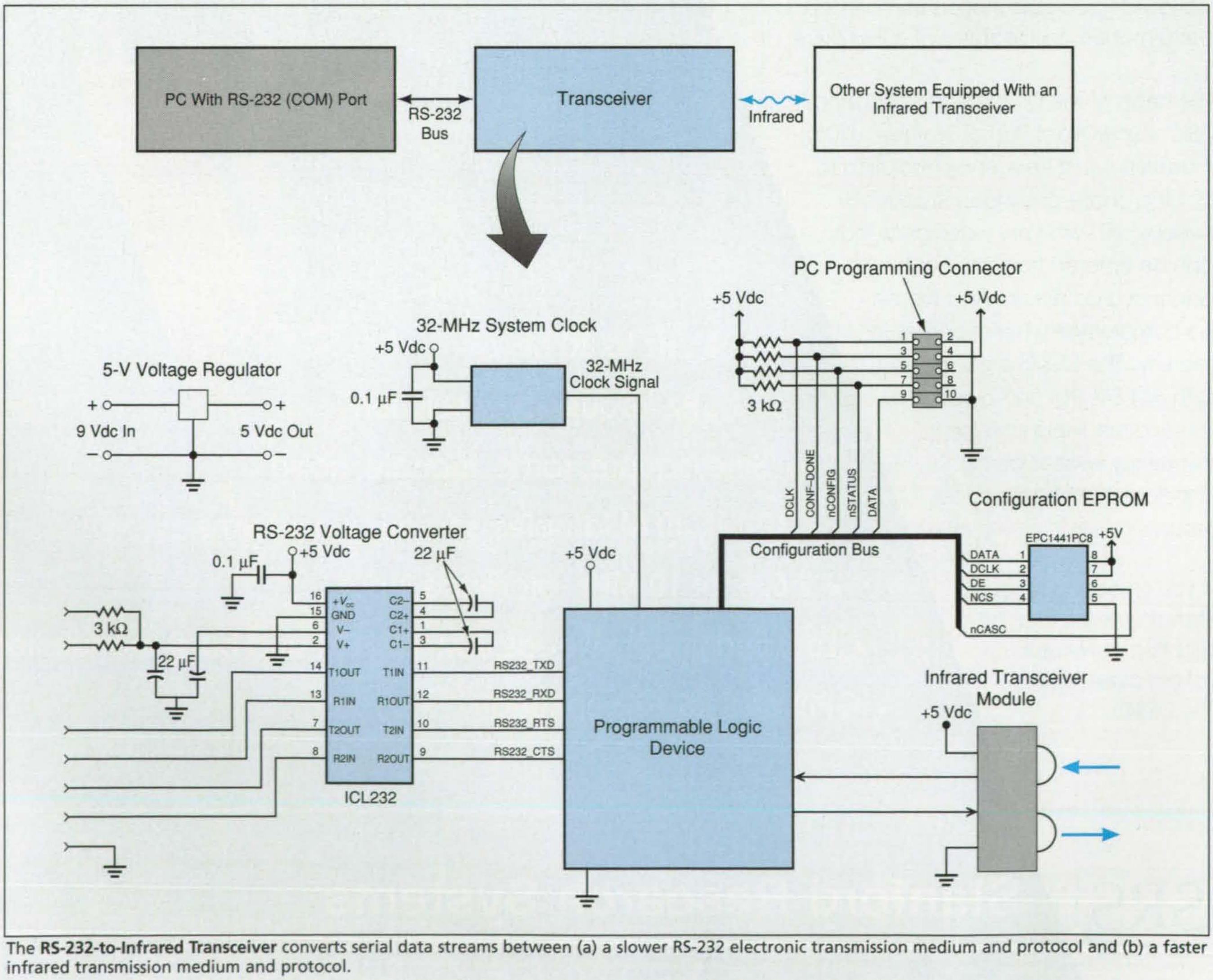
The transceiver includes a commercial off-the-shelf infrared transceiver module designed according to the Infrared Data Association (IrDA) standards, which were developed to promote compatibility among infrared networks for television receivers, computers, and other household devices. In the original application for which the transceiver was developed, there are requirements for small physical size and high flexibility of function for changing the PC baud rate and the sizes of transmitted data blocks. To satisfy these requirements, a programmable logic device (PLD) is included and is programmed with VHDL (very-high-speed integrated-circuit hardware description language).

One of the IrDA standard protocols dictates the use of a 16-bit header on each transmission, with consequent reduction of the effective data-throughput rate. However, the transceiver module is not operated according to this protocol; instead, to increase the data-throughput rate, a protocol that eliminates the 16-bit header was developed and is implemented in the PLD by use of VHDL.

The transceiver circuitry (see figure) consists of seven main subsystems:

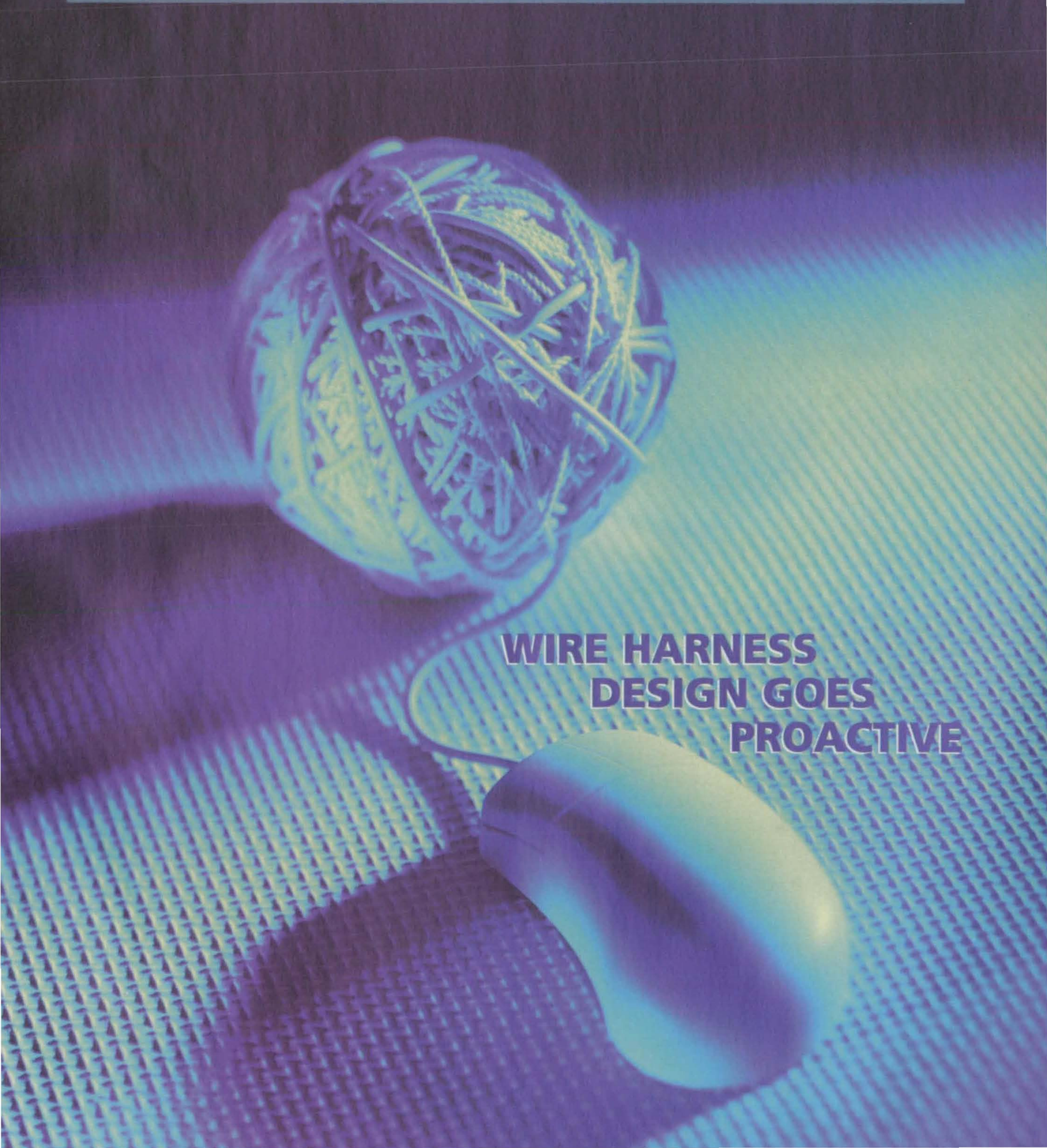
1. *Voltage Regulator*

This circuit converts 9-Vdc power



The **RS-232-to-Infrared Transceiver** converts serial data streams between (a) a slower RS-232 electronic transmission medium and protocol and (b) a faster infrared transmission medium and protocol.

etb
ELECTRONICS TECH BRIEFS



WIRE HARNESS DESIGN GOES PROACTIVE

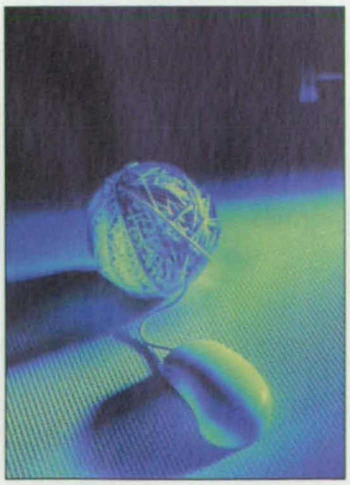
etb
ELECTRONICS TECH BRIEFS

Supplement to
NASA Tech Briefs'
June 2000 Issue
Published by
Associated Business Publications

Feature

Tech Briefs

Department



Design and photograph courtesy Linius Technologies Inc.

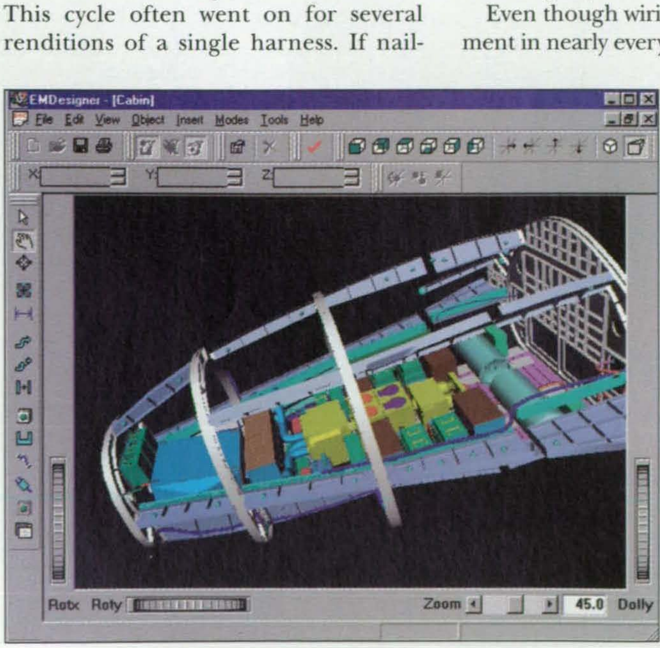
Wire Harness Design Goes Proactive

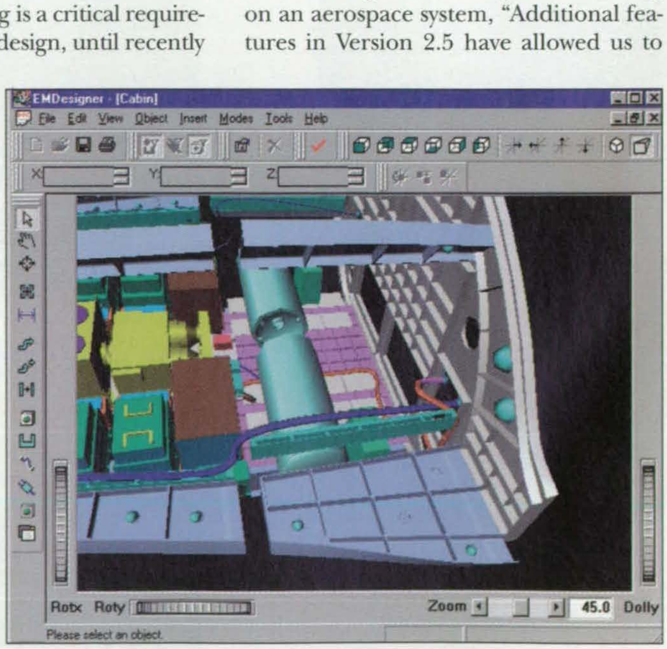
Critical to the completion of any electronic or electromechanical design is the layout and design of the wiring harnesses and cabling systems.

In the past, wiring harnesses were laid in after the electronic components of a system were mounted. The harnesses were then removed and used to erect "nailboards" for use as manufacturing jigs. Multiple nailboards were created for large jobs. Once built, harnesses were tested for crosstalk between power and data lines, and then rebuilt if problems occurred. This cycle often went on for several renditions of a single harness. If nailboards were not used, as in the case of custom or semi-custom orders, a more complex wiring job often turned into a "bucket of worms," according to one engineer. Such a situation not only makes for much difficulty in repeating the work in similar subsequent systems, but it also creates an almost impossible job of troubleshooting near the end of the design cycle.

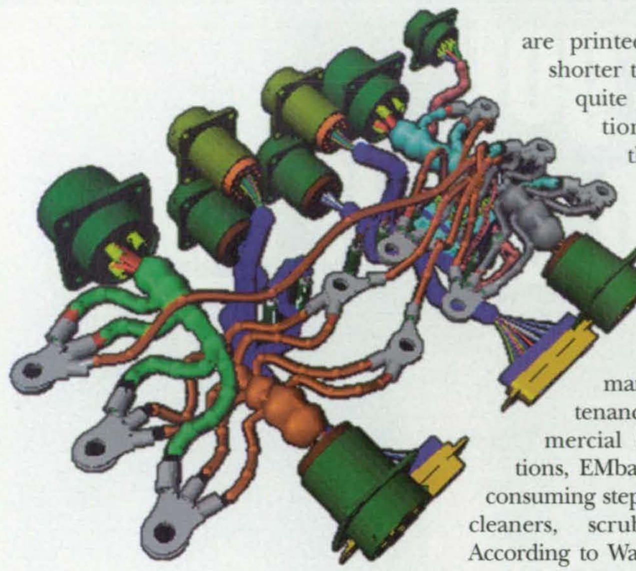
Even though wiring is a critical requirement in nearly every design, until recently no software vendor focused solely on 3D wiring harness design. EMbassy wiring harness software, from Linius Technologies, was prototyped in 1998. Through a concerted effort to increase the functionality of the software to meet the changing needs of the wiring-harness engineer, Linius has produced several revisions to EMbassy in less than two years.

According to one engineer working on an aerospace system, "Additional features in Version 2.5 have allowed us to





EMbassy is being used to develop the wiring system in space vehicles. Configurable DRCs check for redundancy and signal separations.



Wire bundles are color-coded to indicate harness coverings (loom).

provide verification of items we specify ourselves." Using EMbassy, it is easy to double-check bend radii, signal separation, and redundancy separation. As cable size increases, bends and turns in the harness can create stress and strain on the wiring inside the harness as well as at the cable connector. Because EMbassy uses 3D models, wire location inside the cable is considered when wire-length reports are printed. "Coming up with a shorter than needed wire can be quite a time-consuming situation. Furthermore, wires that are cut too long are wasteful of materials. Both these situations are alleviated with the use of EMbassy," said an engineer in an interview.

At Nilfisk-Advance, a manufacturer of floor maintenance equipment for commercial and industrial applications, EMbassy has removed a time-consuming step in the design of vacuum cleaners, scrubbers, and sweepers. According to Wayne Lorenz, an electrical engineer, "We no longer need to create a physical model of the machine we're designing." Engineers at Nilfisk-Advance used to make a nonworking model of their latest design and then take measurements for the cable design. "Now we bring in a Pro/E model and lay out the harness in the 3D model itself. We can actually see where the cable will go without the need for the physical model." In this way, harnesses can be created as the job is being designed. Changes can be made quickly as well.

Lorenz says that he will typically design up to four harnesses for each piece of equipment. Some of the harnesses carry up to 100 wires. When asked what specifically made his job easier, he responded, "What I really like about EMbassy is that it automatically figures out the wire lengths and creates a complete bill of materials. I no longer have to manually add up this bill. The computer takes out a lot of the human error."

Swapping Out

In the design cycle, a 3D model of the electromechanical assembly is imported into EMbassy. Using this model enables the harness engineer to lay out the wiring by defining routing channels. Design rule checks (DRCs) take into consideration that you need a power and return line together, or that you have a certain number of data lines that must always run together. Through the layout of the simulated wiring harness directly within the context of the 3D model, all bends can be calculated, hardware located, and wire cut-lengths calculated. Cable diameters can be preset as well. Engineers can create a harness, check and verify the data, and then make corrections quickly and easily.

Wiring templates on today's high-tech systems become very complex, particularly when tying multiple electromechanical and electronic devices together to create a unique system for a series of specific applications, whether for the automotive, aerospace,

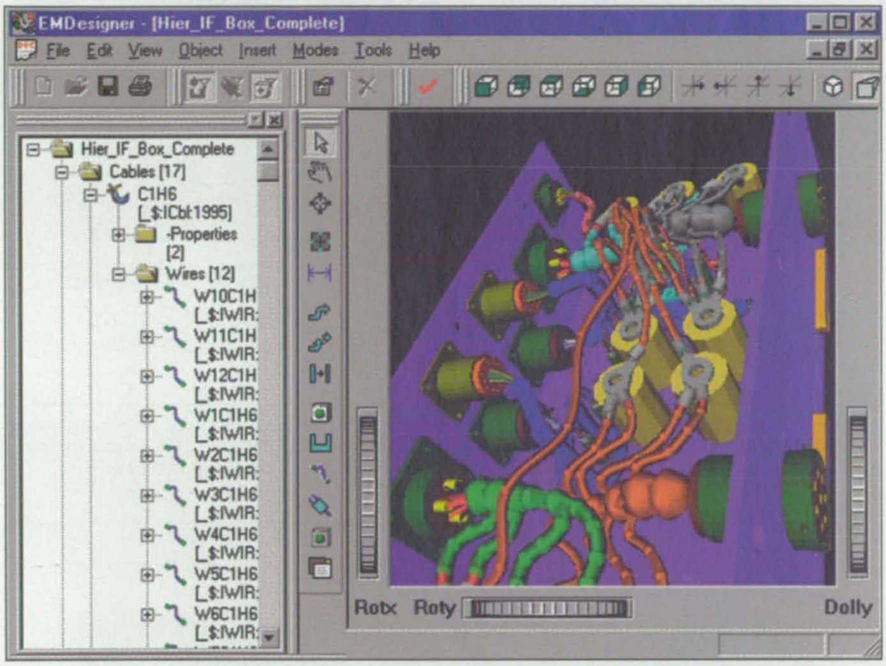
An on-line wiring harness site

Harness.Hub.com was designed to streamline data communication and collaboration among all those involved in the development of wiring harnesses and cable assemblies. Wiring designers, manufacturers, part vendors, and tooling suppliers can now easily share and communicate design data electronically and at one central location.

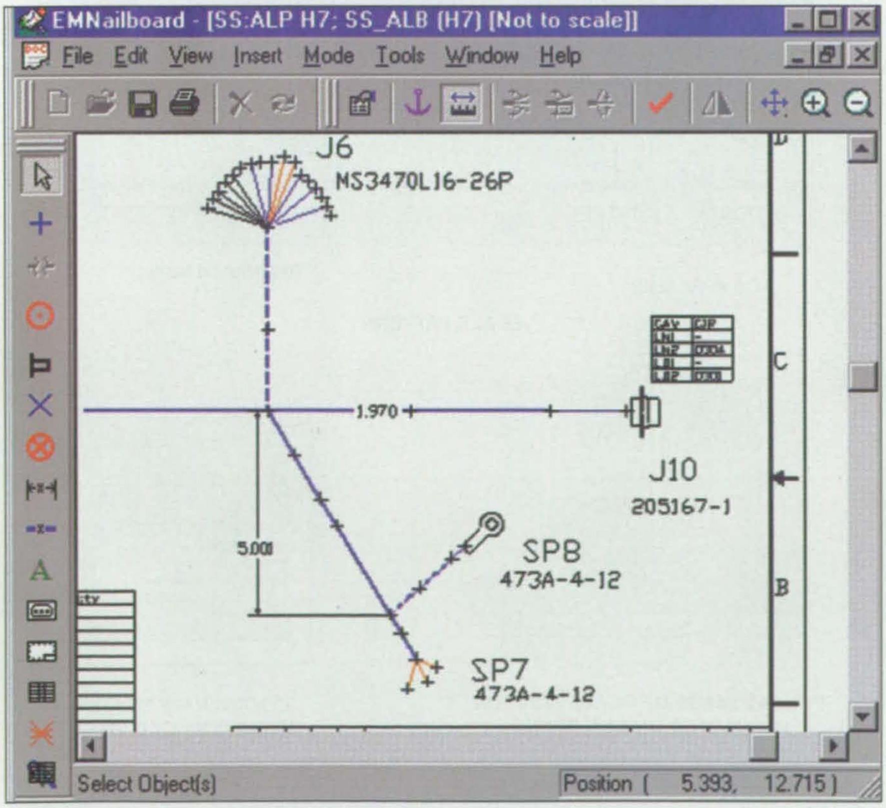
HarnessHub.com also helps in workflow management through an on-line process that mimics the work-in-process atmosphere present in many supply chains. The benefits of performing any function on-line are speed and efficiency. The site will also devote space to the development and communications necessary to produce standards for electronic formats, such as design data (bill of materials, wireless, nailboard) as well as quality issues and other Wiring Harness Manufacturers Association standards.

factory automation, semiconductor, or other markets. Through the use of splice tables, spider diagrams, and parts lists for the hundred of parts involved in harness design, not only has design gotten easier when using EMbassy, but documentation is now performed with a click of the mouse.

A common design challenge that often crops up is the need to swap out one component with a replacement. This is often done because of long lead times from a manufacturer, forcing the design to change. If a different device is specified into the job, the connector pinouts might be completely different, its location shifted, and the type connector used might be different. With EMbassy, these changes can be incorporated before the harness is even built the first time. Through the ability to automate the wire harness d-esign, engineers gain more time to focus on optimizing the form, fit, function, and quality of the design itself. EMbassy automatically checks company-specific design rules, ensures proper shielding between power and data wires, and generates accurate documentation for manufacturing.



By designing wiring within the context of a 3D model, wire lengths and bundle diameters are accurately calculated.



To-scale nailboards and not-to-scale drawings are automatically created and kept in sync with the design data.

Finally, size and weight of every component inside a system has become an important issue design engineers must address. For aerospace systems alone, weight directly affects launch costs, which can be in the tens-of-thousands of dollars range. Today's market requires that most equipment be tightly packed inside an enclosure. Therefore, designers have to watch carefully how the wire harnesses are routed. EMbassy alleviates the problems associated with this type of challenge through its 3D functionality alone. When a harnessing job requires several hundred to a thousand different cables, the time and cost saved through the use of computer automation packages such as EMbassy is phenomenal.

Ending the Tedium

Version 2.5 of EMbassy provides the user with numerous added features and benefits over earlier versions. For example, as mentioned above, the user can now define custom design rule checks. The bend radius check on individual wires has been extended to channels. Part of the 2D documentation and manufacturing functions now include harness drawings that allow the user to stretch or shrink individual channel segments (not-to-scale). A channel snap function enables users to specify a snap angle to create perfectly straight channels and exact 90-degree bend angles.

For designers, a new attached part type (loom) has been defined to represent channel coverings. Loom length is inherited from the channel it is attached to and the channel diameter is updated with the additional diameter of the loom. Another feature propagates a wire's harness ID to all its related components in the system. This not only includes the pins and connectors the wire is connected to, but also any attached parts, such as terminals, seals, connectors, and loom.

As a final note, Wayne Lorenz of Nilfisk-Advance made a significant observation. "Harness design is not as tedious as it once was," he said. For the engineer who has designed a lot of harnesses in his or her career, this may be the statement that hits closest to home.

For more information contact Linius Technologies, Inc., 276 Turnpike Rd., Westborough, MA 01581; phone: (508) 616-9359; fax: (508) 616-9362; web: www.linius.com.

Absolute Position Encoders Using Pattern Recognition

Advantages include longer travel at high resolution, low cost, and less sensitivity to damage.

Goddard Space Flight Center, Greenbelt, Maryland

Innovative optoelectronic encoders for measuring absolute, linear or angular position with super-high resolution have been invented. The new encoders rely on a combination of high-accuracy microlithography, optical projection, charge-coupled-device (CCD) array image detection, and image processing. Compared to conventional absolute encoders, the new encoders allow practically unlimited travel at exceptionally high resolution and are far less susceptible to scale damage or contamination.

Figure 1 is a block diagram of this type of encoder for measuring either linear position along an axis perpendicular to the page or rotary motion about a vertical axis in the page. The encoder includes a scale (as described below) that encodes linear or angular position and is attached to an object of interest which moves with respect to the remaining fixed parts of the encoder. The position encoding pattern on the scale comprises transparent marks on an opaque background such as clear areas in opaque chrome on a glass scale or a perforated metal tape. A printed pattern of light marks on a dark background could also be used in reflection.

A light source illuminates the scale from underneath in the figure, and a lens projects an image of the moving scale onto a CCD array in the camera head. The output of the CCD is processed though an analog-to-digital converter (ADC); the resulting digital image data are stored in an image memory. An image-data processing computer ("image processor" for short) analyzes the image data using pattern recognition algorithms, utilizing the known positions of the pixels in the image, to determine the absolute linear or rotary position of the scale pattern in the reference frame of the stationary parts of the encoder.

The upper part of Figure 2 shows an example of part of the pattern on a linear encoder scale (the pattern on a rotary scale is similar but fanned). In this case, the scale is for measuring position along a horizontal axis in the page. The pattern includes fiducials, smaller marks denoting code bits, and horizontal pattern registration marks. Together, a fiducial and its associated code bits and registration mark form a code group. The pattern of successive fiducials is strictly periodic in the direction of motion. The code bits in a code group

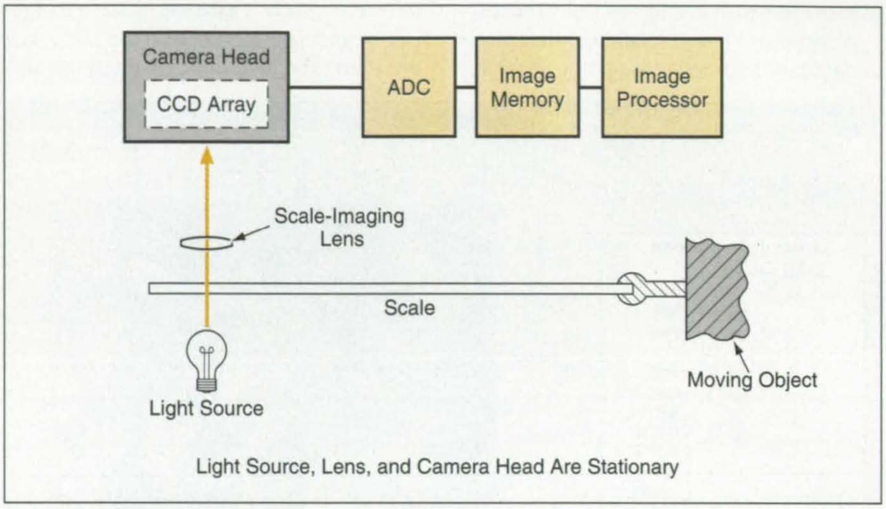


Figure 1. **Light Passing Through the Scale** attached to the moving object is focused to form an image of the scale pattern on the CCD. The remaining circuitry analyzes the pattern to determine the position of the object along the axis of motion, which is orthogonal to the page in this view.

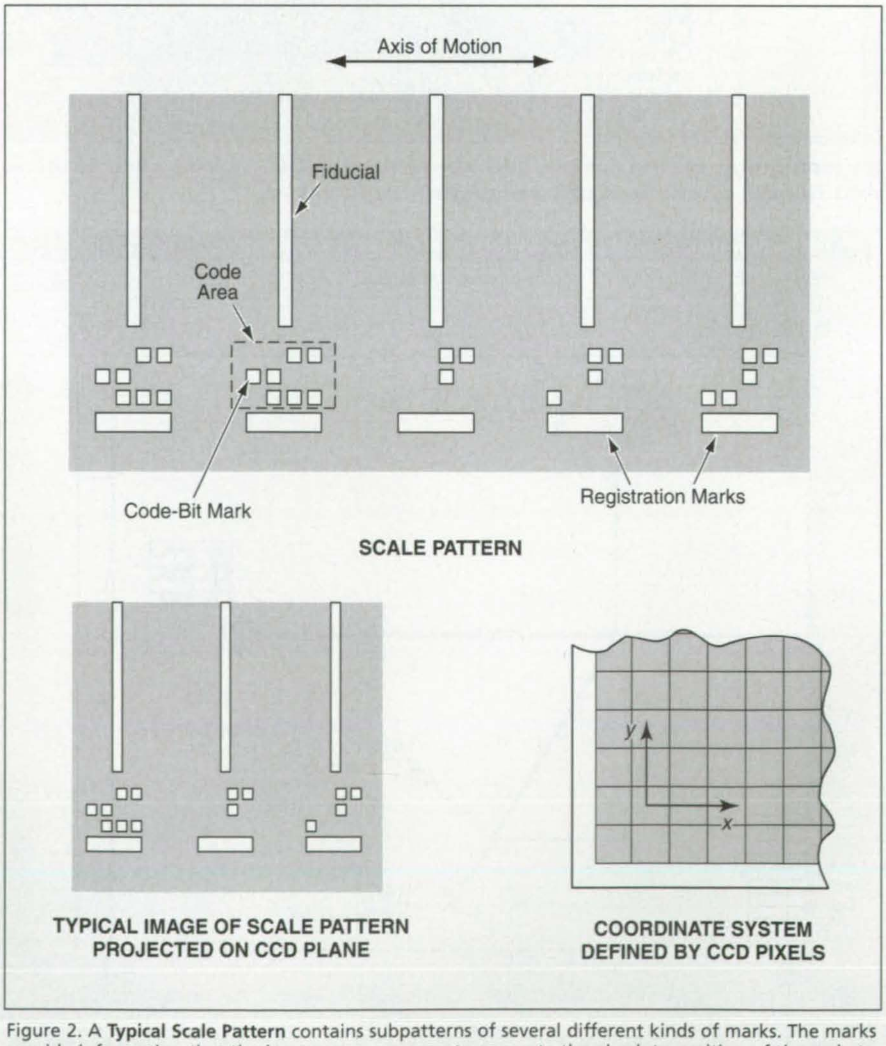


Figure 2. A **Typical Scale Pattern** contains subpatterns of several different kinds of marks. The marks provide information that the image processor uses to compute the absolute position of the scale to high resolution.

uniquely identify each fiducial. The bit pattern could be chosen to represent any convenient binary code; in this example, three rows of four bits each define a 12-position grid, so that each code group identifies one of 2^{12} or 4,096 fiducials.

The image processor utilizes the information in the image of the scale to determine the position of the scale along the axis of motion. For this purpose, one of the axes of the CCD array is aligned along the axis of motion so that the pixel pattern can readily be used as a reference frame. In effect, the binary codes themselves provide low-resolution, absolute position information by identifying which fiducial(s) is (are) imaged on the CCD at any particular time. The absolute position is determined to high resolution by finding the horizontal position of the image of each fiducial in the pixel coordinate frame. This could be done by any of such well-known image processing techniques as edge detection, peak detection, differentiation, or centroiding. However, because optically the centroid of each fiducial image moves linearly across the CCD with scale motion, the preferred technique is centroiding; that is, computing the one-dimensional centroid of the fiducial along the axis of motion in the pixel coordinate system.

For a given encoder geometry and CCD configuration, there is a scale pattern that is optimum in the sense that it yields the most reliable outcome with the highest sensitivity and accuracy with respect to true position. The use of a larger, more sophisticated CCD array enables the simultaneous acquisition of images of several code groups. Position data become more accurate if independent position determinations can be made for multiple code groups. It is desirable to select the scale pattern, optical magnification, and detector geometry to provide the images of at least two and sometimes three (depending on position) code groups on the CCD array. If more than one code group is in view at all times and if there are any variations in magnification, then those variations can easily be corrected because the true spacing of groups on the scale is known and the answer for each group must match as there is only one position being measured.

The arbitrary, multi-bit coding scheme makes it simple to extend the range of linear motion without sacrificing resolution. In a representative example, 12 code bits for fiducial bars spaced by 100 μm would make it possible to encode motion over a range of 409 mm with a sensitivity of 10 nm. A 15-bit pattern would, in principle, extend this range to nearly 3.3 m at the same resolution. A rotary version of the encoder with a 125-mm-diameter code disk using 12 code bits has a sensitivity of about 0.02 arcsecond. These parameters indicate both a sensitivity and a range considerably greater than prior encoders, even though the scale pattern is very much coarser. The coarser pattern can be manufactured at less cost with higher yield and makes the encoder less sensitive to damage of the scale. The fact that the encoder can produce a correct answer based on an image of a single fiducial also makes the encoder less sensitive to damage of the scale.

This work was done by Douglas B. Leviton of **Goddard Space Flight Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

This invention has been patented by NASA (U.S. Patent No. 5,965,879). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center; (301) 286-7351. Refer to GSC-13703.

Carbon Nanotubes as Anodes in Rechargeable Lithium-Ion Cells

etb COMPONENTS

The discharge capacities of these nanotubes exceed those of other forms of carbon.

John H. Glenn Research Center, Cleveland, Ohio

Carbon nanotubes (also known as "bucky tubes") have shown promise for use as anode materials in rechargeable lithium-ion power cells. In comparison with graphite and other forms of carbon used under identical conditions, bucky tubes exhibit greater specific discharge capacity and greater specific energy; this increase has been attributed to the greater electronegativity of bucky tubes and the consequent ability of bucky tubes to accommodate more lithium ions per unit of carbon. The success achieved thus far in the development of bucky-tube anodes with high reversible (charge/discharge) lithium-ion capacities is a result of advances in (1) the production of single- and multi-walled bucky tubes by both arc and non-arc techniques, (2) techniques for purification, (3) techniques for opening the ends of the tubes to admit lithium ions for intercalation, and (4) techniques for fabricating electrodes from bucky tubes.

A recent experimental investigation undertaken as part of this development emphasized the electrochemical performances of open-ended single- and multi-wall bucky-tube anodes in half-cell tests. (In practical full cells, bucky tubes as anode materials would be used in conjunction with $LiNiO_2$, $LiMnO_2$, or $LiCoO_2$ as cathode materials.) In the tests, anodes made from open-ended single-wall bucky tubes exhibited specific discharge capacities as high as 640 mAh/g, and anodes made from open-ended multi-wall bucky tubes exhibited discharge capacities of about 385 mAh/g. In contrast, the theoretical limit of capacity of graphite is only 372 mAh/g.

This work was done by R. O. Loutfy, S. Hossain, and M. Y. Saleh of Materials and Electrochemical Research Corp. for **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16727.

Resonant Crackwires for *In Situ* Monitoring of Jet Engines

etb TEST AND MEASUREMENT

Early detection of fatigue cracks could save lives and reduce costs.

John H. Glenn Research Center, Cleveland, Ohio

Fatigue cracks and plastic deformation of parts in jet aircraft engines could be detected, even during engine operation, by use of proposed *in situ* monitoring devices called "wireless resonant crackwires." Inasmuch as uncontained turbine failures are the leading engine-related hazard for aircraft, early detection

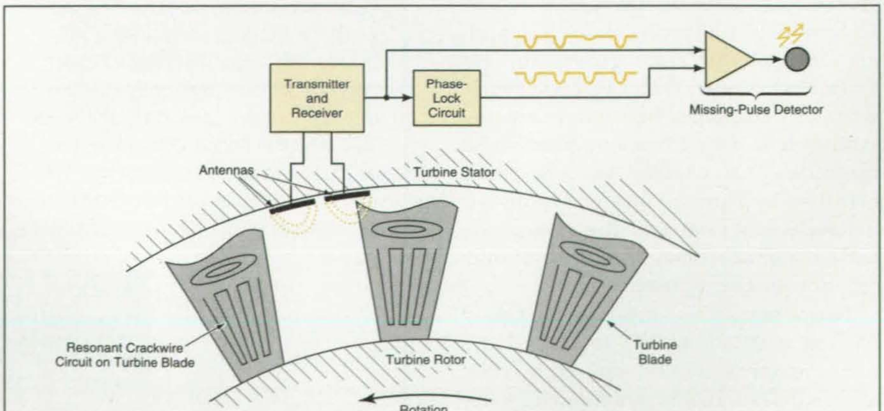


Figure 1. **Resonant Crackwire Circuits** would be bonded to the surfaces of turbine blades. In this example, the crackwire circuits on all the blades would resonate at the same frequency, so that each one would be expected to respond with a pulse when it passed by a transmitting/receiving antenna operating at that frequency. If the circuit on a passing blade were not to respond, a crack alarm for that blade would be triggered.

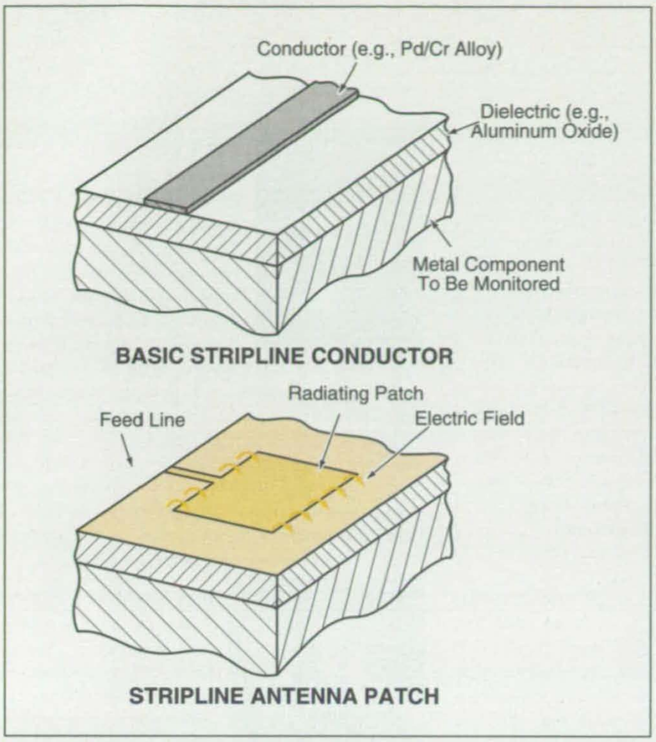


Figure 2. **Stripline Design** would likely be used for a resonant crackwire circuit on a metal component because it would be compatible with the conductivity of the component and the thin-film nature of crackwire circuitry.

of cracks and/or the associated plastic deformation could enable pilots to respond in time to save lives and limit damage. The use of wireless resonant crackwires could also reduce the costs of inspecting engines for fatigue cracks: Often, cracking occurs in engine parts that are accessible only through disassembly of engines. In many cases, the costs of disassembly and reassembly far exceed the costs of inspection, and the disassembly and reassembly processes can cause new damage.

The term "wireless resonant crackwire" is not oxymoronic, though it may appear so at first. "Wireless" as used here represents the absence of wire connections with external equipment and the use of radio signals to interrogate the crackwires.

The principle of operation of wireless resonant crackwires would be an extension of that of radio-frequency (RF) security tags attached to merchandise in some department stores. These tags contain circuits that resonate at frequencies in the vicinity of 9 MHz. Upon leaving a store, a customer must pass by a large loop antenna that emits a signal swept in frequency over a range that includes the resonance frequencies of the security tags. If a security tag has not been deactivated, then it responds to the incident RF signal by ringing and reradiating at its resonance frequency. A second antenna picks up the reradiated signal, and the antenna output triggers an alarm.

To enable the customer to carry the merchandise out of the store without triggering the alarm, a clerk deactivates the tag. Deactivation is accomplished at the store checkout counter by placing the tag on a small antenna that exposes the tag to an overload-level replica of the exit signal in order to burn out a fusible link in the tag circuit. The removal of the link either makes the circuit nonresonant or else moves the resonance to a frequency outside the range of the security equipment.

Resonant crackwires would be bonded to the surfaces of such critical jet-engine components as turbine blades (see Figure 1). Like department-store security tags, resonant crackwires would include links designed to be broken to alter RF resonances. However, these links would not be broken by overload signals; instead, they would be broken by the development of cracks and/or plastic deformation in the engine components to which they were bonded. Thus, if a resonant crackwire monitored by use of a suitable transmitter, antennas, and receiver were to stop resonating at its "installed" resonance frequency, a crack alarm would be triggered.

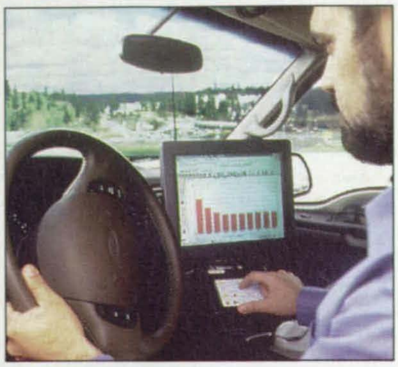
Of course, because of the unique characteristics of the jet-engine environment (especially high temperature and the metallic nature of the components to be monitored), the design and fabrication of resonant crackwires would differ markedly from those of department-store RF security tags. Resonant crackwire circuits would likely be fabricated by use of techniques developed previously for strain gauges for monitoring engine parts at high temperatures; this would involve the deposition, on the engine parts to be monitored, of thin oxide films as dielectrics and patterned thin films of high-temperature alloys as inductors, electrodes for capacitors, and antennas. The resonance frequencies of these circuits would range upward from several hundred megahertz and possibly into the gigahertz region. In many cases that would involve monitoring of metal components it may prove necessary to resort to stripline circuit designs, utilizing the underlying monitored components as the ground planes of stripline antennas and resonators (see Figure 2).

This work was done by Bruce McKee, Scott Dahl, and Kathy Shkarlet of Innovative Dynamics, Inc., for **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16758.

NEW PRODUCTS

PRODUCT OF THE MONTH



Noise Figure Analyzers

Agilent Technologies, Palo Alto, CA, offers the NFA series of noise-figure analyzers, which consists of two models: the 1.5-GHz N8972A, and the 3.0-GHz N8973A. They provide a real-time display of noise figure or gain versus frequency, easy measurement setup, built-in data storage, and printer connectivity. The N8973A features point or sweep averaging for real-time tuning, and sweep list for point-by-point measurements at specified frequencies. It also provides accurate characterization of individual system components, allowing a designer to determine the noise figure of an entire system. Agilent says the new architecture of the NFA analyzers incorporates a more flexible and intuitive user interface that simplifies noise-figure measurements.

For More Information Circle No. 766

PVDF Capacitive Sensors

The PT30 and KT34 PVDF capacitive sensors from Turck, Plymouth, MN, are barrel-style sensors designed to solve applications in harsh environments. Made of polyvinylidene fluoride (PVDF), the housing, cable, cord grip, and mounting brackets are immune to damage from contact with most industrial chemicals. They detect metallic and nonmetallic materials such as water, metal, wood, glass, plastic, and thin wire. The PT30 is a 30-mm sensor that provides 10-mm sensing range; the KT34 is a 34-mm sensor with a 20-mm sensing range. Both models are available in flush and nonflush mounting styles.

For More Information Circle No. 767

High-Current Inductors

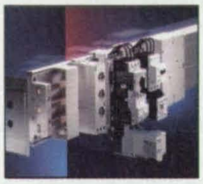
Prem Magnetics, McHenry, IL, has introduced the SPE-400 high-current inductors for use in Switch Mode Power Supply (SMPS) applications. The series of 20 inductors uses a ferrite core construction where coil is wound directly on the core. They are mounted horizontally on the printed circuit board for reduced height requirements. Inductance values range from 0.9 µHy at 13 A DC to 1000 µHy at 0.42 A DC. The inductors have typical physical dimensions of 0.765" x 0.435" x 0.340".

For More Information Circle No. 768

Lamps and Drivers

Durel Corp., Chandler, AZ, offers DUREL® 3 electroluminescent lamps and drivers for backlighting displays and keypads of cellular phones, pagers, and GPS handsets. The lamp construction incorporates a proprietary phosphor technology. Matched systems provide uniform brightness in displays, while maximizing lamp life and minimizing the use of battery power. A variety of system configurations is available for specific applications. According to the company, the lamps provide thinness, flexibility, uniform illumination, and low power consumption.

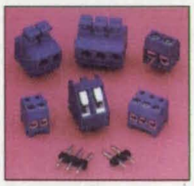
For More Information Circle No. 769



Flat Bushbar Systems

A new flat bushbar system from Rittal Corp., Springfield, OH, is designed to simplify the installation and wiring process of power distribution components within a control panel. The system is rated at 360 amps and offers a 40-mm spacing design. Features include clip-on connections, touch-safe cover system, the ability to integrate single or double DIN-rail-mounted controls, and multifunction adapters rated from 25 to 40 amps. The adapters are suited for industrial control equipment that utilizes IEC-type controls. Available in 45-, 54-, and 90-mm widths, the adapters feature a floating contact system for clip-on/clip-off mounting, wire leads or clamps, and the ability to integrate BUS technology.

For More Information Circle No. 770



Modular PC Terminal Blocks

Keystone Electronics, Astoria, NY, has released horizontal and 45-degree entry, modular PCB-mount terminal blocks, both with two and three terminal positions that can be interlocked to a maximum of 24 positions. The 45-degree entry blocks, designed for use on high-density PCBs, feature easy access to termination points, and are made with the screw heads on top of the blocks. Termination points have a wire guard that helps prevent damage to conductors. The blocks are made of brass tin-plated contacts, blue UL-rated 94V-0 PET housings, and a captivated steel zinc-plated screw. The modular blocks mount on header pins installed into PCBs.

For More Information Circle No. 771

Graphics Controller

The PMC-700 graphics controller from DY 4 Systems, Kanata, ON, Canada, is an IEEE 1386.1 PMC-based mezzanine board that provides graphic functions such as 2D and 3D rendering, video capture and overlay, support for legacy interlaced displays, and anti-aliasing capabilities. The controller combines commercial software, silicon, 3D graphics acceleration, and an X11/OpenGL® programming interface. The controller is designed for implementing human-machine interfaces for critical applications such as cockpit primary flight and digital map displays.

For More Information Circle No. 772

Film Measurement System

ADE Corp., Westwood, MA, offers the AcuMap II film measurement and visualization system that provides an alternative to conventional film thickness measurement systems. It is a full-wafer mapper capable of providing up to 40,000 film measurements across a wafer in less than 90 seconds. The system maps dielectric films and is compatible with 100-200-mm wafers. It employs an optical imaging system that provides high-density resolution of wafer thickness, and permits process characterization of the entire wafer.

For More Information Circle No. 773

AC Inlet/Outlet Connector

The IEC 320 AC inlet/outlet connector with built-in ground clip from Methode Electronics, Rolling Meadows, IL, meets UL and CUL standards, and features a maximum operating voltage of 250V AC at a maximum current of 15 A. Contact resistance is 20 milliohms maximum, with an insulation resistance of 1000 megohms at 1500V AC. The built-in ground clip furnishes direct cabinet grounding, eliminating the need for a separate ground wire or connection. The grounded AC receptacles mate with all industry-standard IEC power cord sets. The contacts and ground clip are made of copper alloy with a tin plating. The insulator is black polycarbonate and carries a 94V-0 rating.

For More Information Circle No. 774

CompactPCI D/A Board

DATEL Systems, Mansfield, MA, has introduced the CPCI-520 four-channel analog output board configured in a single-slot 3U board outline. The board features D/A converters with 2.5-, 5-, and 10-volt output ranges, both unipolar and bipolar. Any channel may be selected for 4-20 mA precision current loops in active mode, not requiring external current loop excitation. Each D/A channel may be set for any of the ranges with five ranges set for 12-bit resolution. All channels update simultaneously when a sample clock is received, either from the on-board programmable timebase, or from an external user-supplied clock input.

For More Information Circle No. 775

Equipment Enclosures

Outdoor WAN aluminum cabinets designed for wireless telecom, datacom, and other applications are available from Pentair Electronic Packaging, Plymouth, MN. The flexible, tested, and prequalified enclosures ensure positive protection for electrical and electronic equipment in harsh outdoor environments. The enclosures can be rooftop- or pad-mounted. They are available in unibody or modular format, in single- or multiple-bay configurations, with mounting for 19", 23", and proprietary racks. Optional heat exchangers and air conditioners are available, among other features.

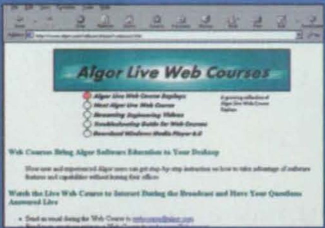
For More Information Circle No. 776

Algor Live Web Courses

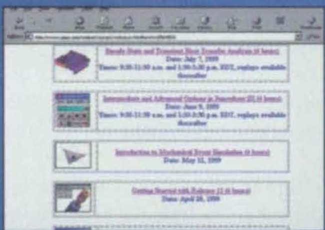
For Training and Education at Your Desk

How to watch an Algor Live Web Course from Algor's web site:

Go to www.algor.com.



Click on the button for "Algor Live Web Courses" to go to the Web Course section or go directly to www.algor.com/webcourse.



View the complete schedule with the course content for each of the past and upcoming Web Courses. Select the Web Course you want to view and contact your Algor Account Representative for a password to gain access to the live broadcast and replays.

After you gain access to the Web Course, watch it live or on replay with no downloading time. You will also get your choice of a VHS videotape or CD-ROM of the Web Course for your resource library.

Now new and experienced Algor customers can get step-by-step instruction on how to take advantage of software features and capabilities without leaving their desk. Each Web Course registration includes:

1

Access to the Live Web Course on the Internet using a password. Viewing the Live Web Course gives engineers the opportunity to phone in or email their questions and participate in the training.

2

Access to the replay of the Web Course for unlimited personal screenings using streaming video format. The streaming video format is a fast response format that "streams" the video over the Internet to the engineer with no download times.

3

A VHS videotape or CD-ROM containing the Web Course enables engineers who do not have Internet access to benefit from Algor's use of Internet audio/video technology. This enables viewers to build a resource library of Web Courses.

Past topics of Algor Live Web Courses are also available for sale in both Internet Streaming Video, VHS videotape or CD-ROM format. See our web site for course listings and details.

A senior Algor engineer responds to a customer's question during a live Web Course.

Algor's Cutting Edge Technology Enables High Audio and Video Quality

All Algor Live Web Courses are broadcasted in three bandwidths with top quality audio to reach viewers on all types of Internet connections from 56k modems to cable modems and T1 lines.

Algor has made a significant investment in webcasting technology to produce Web Courses of the highest possible quality at any bandwidth. High-technology production techniques show the details of Algor software in use at any bandwidth.

FREE SAMPLE: To sample Algor's Web Course technique at no charge, tune into one of our **free public Webcasts** available at **www.algor.com/webcast** that showcase live demonstrations of Algor software capabilities. By calling in, engineers can participate in the live demonstration by having Algor engineers respond to their questions. The Webcasts are then made available for replay after the live broadcast for a personal screening at any time. Visit our web site for a listing of upcoming Webcasts and Webcast Replays.

Algor's Web Courses have qualified for Professional Development Hours (PDH) within those states that have Continuing Professional Competency (CPC) requirements as a condition of license renewal for Professional Engineers.

About the Streaming Video Format

Get Windows Media Player

The streaming video format used for all web broadcasts is designed for Microsoft Windows Media Player. Since most of Algor's customers operate on the Windows 95, 98, or NT platforms, using Microsoft tools such as Windows Media Player and Internet Explorer 4.0 or higher offers maximum compatibility, reliability and through-put. *The latest version of Windows Media Player can be downloaded at no charge from our web site or at www.microsoft.com.*

View Schedule of Upcoming Web Courses and Web Course Replays at:

www.algor.com

Email questions before or during a Web Course to: webcourse@algor.com. Or phone your questions directly to an engineer during the Web Course at: +1 (412) 967-2700 x3014.

ALGOR®

When the Engineering Has to be Right

Algor, Inc.
150 Beta Drive, Pittsburgh, PA 15238-2932 USA
Phone: +1 (412) 967-2700
Fax: +1 (412) 967-2781
California: +1 (714) 564-0844
Europe (UK): +44 (1784) 442 246
Email: info@algor.com
www.algor.com

from a wall transformer unit to 5-Vdc power used by the other subsystems.

2. *RS-232 Voltage-Level Converter*
   This circuit converts RS-232 transmitting (TxD) and receiving (RxD) ±10-Vdc logic levels to +5/0-Vdc logic levels used in the PLD.
3. *System Clock*
   The system clock operates at a frequency of 32 MHz (instead of 4 MHz) because 8¥ over-sampling of the 4-MHz received infrared signal is required for the 4-MHz receiving logic in the PLD. The system clock also provides a master clock signal that is divided in frequency down to 921.6 kHz to enable 8¥ over-sampling for the 115.2-kilobaud RS-232 receiving logic.
4. *Infrared Transceiver Module*
   This module contains an infrared light-emitting diode (LED) and an optically gated transistor that operate at the same wavelength. Because it is an IrDA-standard module, it is compatible with commercial electronic devices.
5. *The PLD*
   The PLD contains all the logic circuitry needed for conversion between an RS-232 data stream and a faster infrared data stream. Thus, most of the functionality of the transceiver is implemented in the PLD.
6. *Configuration EPROM*
   The configuration erasable programmable read-only memory (EPROM) is used to reconfigure the logic in a the PLD, which logic is based on a static random-access memory (SRAM). Each time power is turned on, the PLD is configured with its hardware logic. Changes in the logic are implemented by changing or reprogramming the configuration EPROM.
7. *PC Programming Connector*
   This is a socket for a cable connection to enable the use of a PC to program the PLD. This socket is used temporarily — during development — for configuring the PLD directly from a PC without reprogramming the EPROM.

This work was done by Brandon Dewberry and Kosta Varnavas of **Marshall Space Flight Center.**

This invention is owned by NASA, and a patent application has been filed. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at (256) 544-5226 or sammy.nabors@msfc.nasa.gov. Refer to MFS-31331.

"Intelligent" Transceivers Would Predict Failures of Parts

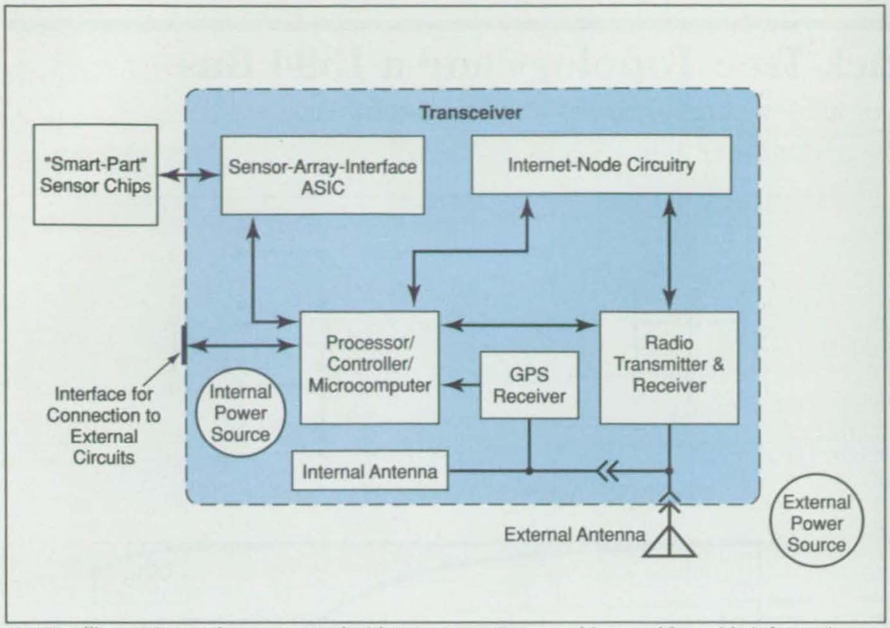
Replacements could be ordered automatically to arrive just in time.

NASA's Jet Propulsion Laboratory, Pasadena, California

Special-purpose, "intelligent," computer-controlled, highly miniaturized radio transceivers have been proposed for use in monitoring critical and/or valuable pieces of equipment. These transceivers and associated electronic circuits would perform both diagnostic and prognostic monitoring functions: They would acquire and provide information on the history and current status of the monitored equipment. On the basis of this information, they would predict impending failures of components. Then they would order replacements for components expected to fail soon or for consumable supplies (e.g., fuel) expected to be exhausted soon; these orders would be submitted so that the needed replacements would arrive just in time.

The intelligent transceivers were conceived as means to relieve highly mobile military forces of much of the burden of maintenance and logistics. They could also prove useful in civilian industries in which it would be cost-effective to anticipate needs to replace components and/or replenish supplies; examples could include the automotive, vending-machine, and shipping industries.

Intelligent transceivers would have dimensions of no more than a few centimeters. They could be mass-produced relatively inexpensively by use of established integrated-circuit fabrication techniques. An intelligent transceiver would be connected with "smart-part" microchips that would be designed into major components and subassemblies of the equipment to be monitored (see figure). These microchips would contain sensors and sensor circuitry for monitoring the physical conditions and statuses of components and subassemblies. The sensors and circuits would be designed



An **"Intelligent" Transceiver** connected with "smart-part" sensor chips would provide information on the status of the equipment in which the sensor chips were embedded.

and calibrated to be especially sensitive to such failure-inducing phenomena as excessive wear, overstress, and temperature anomalies. The output signals from the smart chips would be collected by the transceiver and processed by algorithms that would predict times of probable failure of specific components.

An application-specific integrated circuit (ASIC) within the transceiver would provide the sensor-signal-processing algorithms and would serve as the interface between the rest of the transceiver and the smart sensor chips. During normal operation, the principal function of the ASIC would be to scan the sensors and perform continuous self-interrogation and diagnosis. Meanwhile, the time accumulating on each monitored component would be sent to a transceiver memory for continuous updating. During this operation, anomalies expected to lead to failures would be identified and times to failure would be estimated. The collected data would be processed into "plain-language" text with supplemental information derived from the memory, and requests for replacement of parts expected to fail would be transmitted — all automatically.

Functions and characteristics of intelligent transceivers, in addition to those described above, would include the following:

- Each transceiver would contain a small battery or other power source and a small antenna for transmitting and receiving over a limited range; however, in normal operation, it would be connected, via a standardized receptacle, to a larger antenna and a power source in the monitored equipment to enable communication over a longer range.
- Although a transceiver would automatically signal the need for replacement of parts or other maintenance actions, it could also be interrogated manually for information on the status of the monitored equipment.
- Each transceiver would record the maintenance history of the monitored equipment.
- All components of the monitored equipment would be identified, in a transceiver memory, by part numbers.
- Instructions for repair and replacement would be contained in each transceiver memory and would be accessible via an infrared link to a display unit.
- Each transceiver would contain a Global Positioning System (GPS) receiver.
- Each transceiver would be capable of autonomously communicating with other transceivers to ascertain their locations.
- A transceiver on a damaged piece of equipment could interrogate other damaged pieces of equipment to determine what components could be salvaged and whether a replacement for a damaged component in its own damaged piece of equipment was locally available.
- Each transceiver would be capable of "learning" and updating its "knowledge" of the rates of wear of critical components.

This work was done by Philip Moynihan and Govind Deshpande of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
NPO-20699

Networks Based on Stack-Tree Topology and a 1394 Bus

COTS circuits can be configured to achieve high degrees of fault tolerance.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of designing fault-tolerant networks of computers and other electronic circuits has been conceived with a view toward minimizing costs by utilizing commercial off-the-shelf (COTS) products and standards for all system and component interfaces. The method involves, more specifically, utilization of selected features of the 1394 bus architecture and of the stack tree-topology (see Figure 1), which is a special case of the general tree topology and which complies with the 1394 standard. Of particular significance in the method is a specific type of stack tree denoted as Complete Stack Tree (CST) of *n* stem nodes.

Taken by itself, the stack-tree topology is not fault tolerant: failure of any link partitions a stack tree into two segments, while failure of a stem node can partition the tree into two or three segments, depending on the specific design. Moreover, the 1394 standard does not permit loops, which would be formed if, for example, one were to connect the leaf nodes of a CST with spare links. However, the 1394 standard provides a "port disable" feature, which can be utilized to make any spare links "invisible" to the rest of the network. In the initial configuration of the network, the ports connected to the spare links are disabled, thereby disabling the spare links and preventing the formation of loops. In the event of failure of one or more nodes or a link of the initial network configuration, messages can be rerouted around the failed parts by enabling the appropriate ports to activate the appropriate spare links.

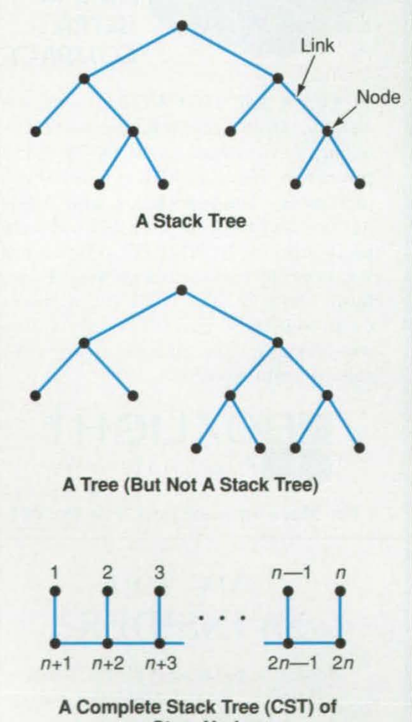


Figure 1. **Stack Trees** are constructed from three-port nodes. A leaf node is one that is connected to one other node denoted a stem node. Each stem node is connected to at most three other nodes, of which no more than two are stem nodes. A complete stack tree (CST) is one in which each stem node is connected to at least one leaf node.

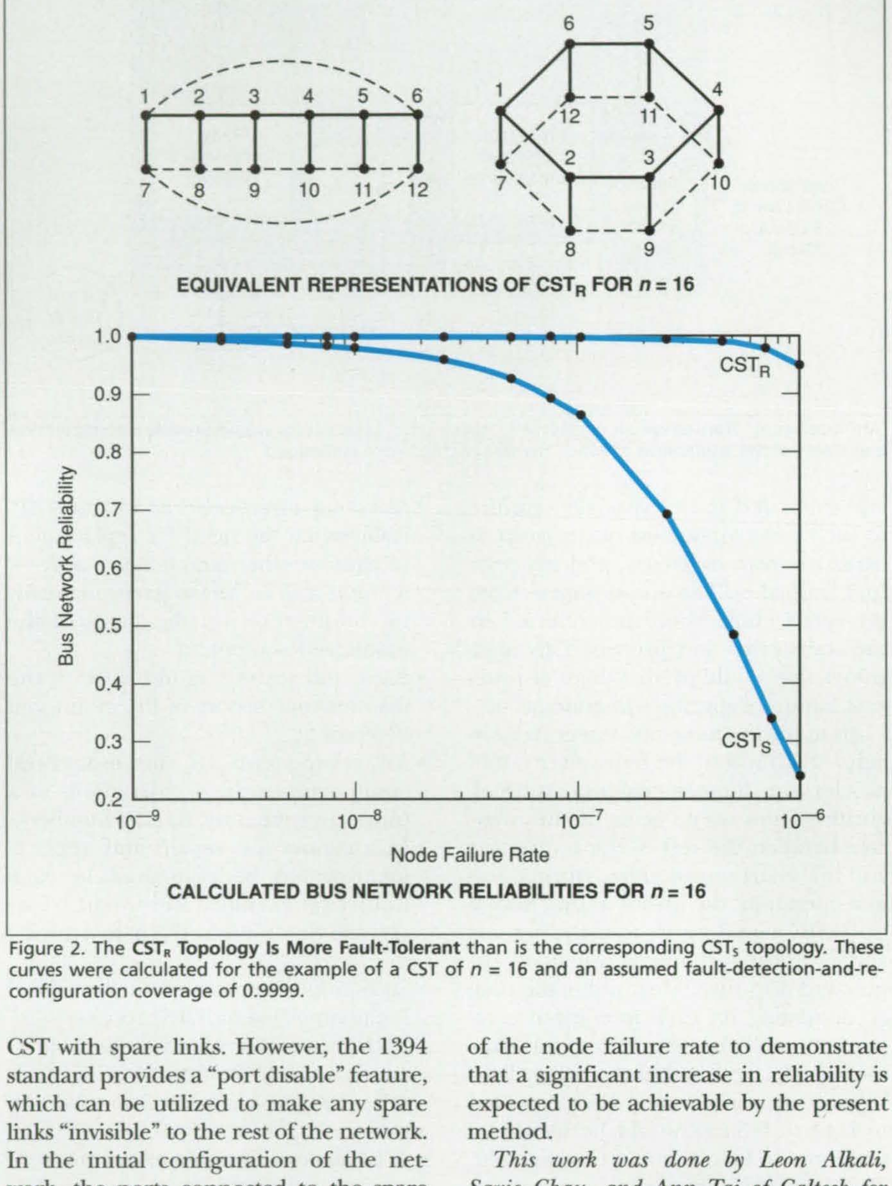


Figure 2. The **CST$_R$ Topology Is More Fault-Tolerant** than is the corresponding CST$_S$ topology. These curves were calculated for the example of a CST of n = 16 and an assumed fault-detection-and-reconfiguration coverage of 0.9999.

The upper part of Figure 2 schematically depicts a complete stack tree without spare links [denoted a "simplex complete stack tree" (CST$_S$)] and a complete stack tree with a spare link constructed to obtain a configuration called "CST$_R$" (where "R" refers to the fact that the resulting network topology is ringlike). The lower part of Figure 2 presents an example of calculated bus network reliabilities as functions of the node failure rate to demonstrate that a significant increase in reliability is expected to be achievable by the present method.

This work was done by Leon Alkali, Savio Chau, and Ann Tai of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Technology Reporting Office
JPL
Mail Stop 122-116
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

Refer to NPO-20817, volume and number of this NASA Tech Briefs *issue, and the page number.*

Special Coverage: Computers & Peripherals

The OmniMeter™ Elf™ **single-board computer** from DVP, Rockville, MD, measures 12 square inches and features audio and telecom peripherals, 12 additional discreet keys, and a second serial port. It comes with direct support for various QVGA displays, including an extended temperature-range QVGA monochrome display with integral touchscreen.

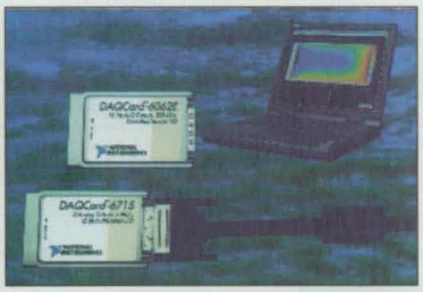
The computer is a StrongARM-based platform for OEMs developing handheld computers. The system features onboard NiMH and NiCAD battery charging circuitry, low-power DRAM, onboard multi-voltage power supply, and 10-bit A/D converter, 10-general-purpose I/O pins. It supports Windows CE, embedded, and Linux platforms.

For More Information Circle No. 727

CyberResearch, Branford, CT, offers the MSC series of ultra-compact industrial **PC workstations** with 6.4" TFT LCD displays. The MSC 06 features an embedded 486DX4, 100-MHz CPU card, and an optional analog resistive touchscreen. The MSC 06H development PC system also features a HideAway™ 6.4" TFT LCD color display mounted inside the unit's hinged front cover.

The MSC 00 base system does not include a built-in LCD display, but is available with two different embedded 486DX4, 100-MHz CPU card options, both of which include a PC/104 connector for accessories. All MSC series workstations feature a wall-mountable steel chassis, 32 MB RAM, 2.5" 6-GB hard disk drive, 55W power supply, DOS software, and built-in 10Base-T Ethernet port.

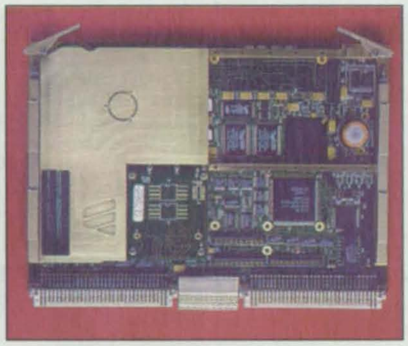
For More Information Circle No. 728



National Instruments, Austin, TX, has introduced the DAQCard-6062E and DAQCard-6715 **PCMCIA cards for laptop computers**. The 6062E is a 12-bit, 500 kS/s multifunction I/O card with analog output waveform capability. The 6715 is an 8-channel analog output PCMCIA card with the ability to generate waveforms at 1Ms/s. Both cards feature a shielded latching connector that keeps the cable attached to the card.

The boards include NI-DAQ™ driver software for use with numerous programming environments and languages with NI PC-based data acquisition products. The software works with PCMCIA, PCI, PXI/CompactPCI, ISA, and IEEE-1394 platforms. The cards are used for creating waveforms in process control applications, audio testing, and vibration analysis.

For More Information Circle No. 726



The PENTX2 **single-board computer** from MATRIX Corp., Raleigh, NC, is available in 6U VMEbus, convection-cooled, militarized, conduction-cooled, and non-VME versions. The computer is based on the 266-MHz Pentium®II and 440BX support chip set. The system supports ISA peripherals such as keyboard, mouse, serial ports, parallel ports, IDE, and floppy disk interfaces.

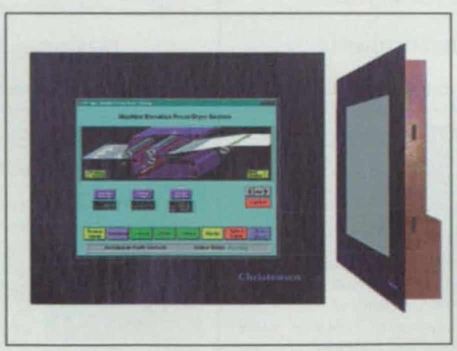
It supports Ultra SCSI, 10Base-T and 100BaseTX Ethernet, one PCI mezzanine card slot, and AGP graphics functions. Also available is a FLASH disk that functions as an IDE disk drive and USB port. The system memory interface supports memory sizes from 32 to 128 MB SDRAM.

For More Information Circle No. 729

Accuride International, Santa Fe Springs, CA, offers two **keyboard tray systems** mounted on fully concealed Accuride slides. Both the deluxe and standard systems feature an angled keyboard platform and a 30"-wide tray that provides a mousing surface on either side. The trays feature a curvilinear, ergonomic design for user comfort.

The trays feature three typing positions. Each tray comes with a removable gel or foam palm rest that allows the system to accommodate virtually any keyboard. An installation template and heavy-duty brackets are included.

For More Information Circle No. 731

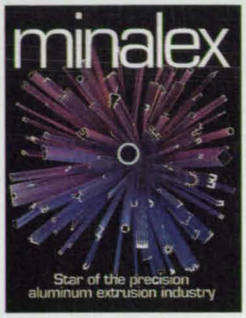


Christensen Display Products, Preston, WA, has introduced the LS10 10.4" **flat-panel monitor** series, available in a variety of mounting and touchscreen configurations. The monitors offer up to 800 x 600 resolution, 16-bit color, wide viewing angles, and direct compatibility with any standard analog video signal.

They feature a true 10.4" diagonal viewing area, which is as large as a traditional 12" CRT monitor, but with less depth and weight. The monitors use the same interface as the company's larger industrial flat-panel monitor products.

For More Information Circle No. 730

LITERATURE & WEB SITE SPOTLIGHT



PRECISION ALUMINUM EXTRUSIONS

New! An informative brochure from MINALEX, leader in close tolerance shapes to 3 1/2", illustrates typical applications and describes capabilities including short runs. MINALEX, quality leader, delivers on time, every time. MINALEX, PO Box 247, Whitehouse Station, NJ 08889; Tel: 908-534-4044; Fax: 908-534-6788.

Minalex

For More Information Circle No. 607

KEITHLEY'S 2000/2001 CATALOG

Keithley's 2000/2001 catalog of computer-based measurement products provides specifications, selection guides, and background on measurement techniques. Products include voltage, current, and resistance meters; sources, switches, software, real-time control hardware, signal conditioning hardware; acquisition, digital I/O, and motion control boards; and semiconductor products. Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, OH 44139; Tel: 1-888-KEITHLEY; www.keithley.com

Keithley Instruments, Inc.

For More Information Circle No. 608

100,000 PROCESS MEASUREMENT AND CONTROL PRODUCTS

More than 100,000 process measurement and control products can now be ordered directly via OMEGA Engineering Inc.'s new online store at www.omega.com. Most items are in stock for overnight delivery. Products include thermocouple and RTD probes; instruments for temperature measurement and control; pressure transducers and load cells; plus a full line of data acquisition products. OMEGA Engineering Inc.; One Omega Dr., P.O. Box 4047; Stamford, CT 06907-4047; Tel: 800-826-6342; Fax: 203-359-7700; e-mail: info@omega.com; www.omega.com

OMEGA Engineering Inc.

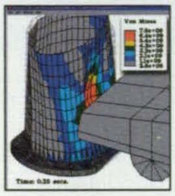
For More Information Circle No. 609

EXPERIENCE THE POWER OF FEA THROUGH INTERNET TV DISTANCE LEARNING

Visit www.eTechLearning.com to access a free web course preview and get schedule and ordering information. For as little as $350, web courses let you learn at your own pace with on-demand replays and a library copy video or CD-ROM. In addition, these courses have qualified for Professional Development Hours toward P.E. license renewal. Address: 150 Beta Dr., Pittsburgh, PA 15238; Phone: +1 (412) 967-2700; E-mail: info@algor.com; or Fax: +1 (412) 967-2781; www.eTechLearning.com, www.algor.com, www.pipepak.com, www.feaincad.com

Algor, Inc.

For More Information Circle No. 610



ALGOR'S ACCUPAK/VE SOFTWARE REPLICATES REAL-WORLD EVENTS

In this impact simulation, Algor's Accupak/VE Mechanical Event Simulation software and kinematic element technology replicates physical behavior by determining the motion, flexing and resulting stresses of a CAD part or assembly in a "virtual laboratory." Add thermal, fluid or electrostatic effects to Accupak/VE analyses with linear and nonlinear materials to simulate multiple physical phenomena. Address: 150 Beta Dr., Pittsburgh, PA 15238; Phone: +1 (412) 967-2700; E-mail: info@algor.com; or Fax: +1 (412) 967-2781; www.algor.com

Algor, Inc.

For More Information Circle No. 611

TUESDAY @ TEN: INTERNET TV DISTANCE DEMOS SHOW WHAT'S NEW

Join Algor every Tuesday at 10 a.m. Eastern Time at www.eTechLearning.com to learn about Algor's Finite Element Analysis and full Mechanical Event Simulation software and its InCAD products for doing FEA within CAD. Viewers can phone or e-mail questions to be answered by Algor engineers during these free, public Webcasts. Replays are available on demand. Phone: +1 (412) 967-2700; E-mail: info@algor.com; or Fax: +1 (412) 967-2781; www.eTechLearning.com, www.algor.com

Algor, Inc.

For More Information Circle No. 612

SOFTWARE SHOWCASE

Software Showcase provides you with information and demonstrations of industry-leading National Instruments application software for measurement and automation applications, such as LabVIEW™, LabWindows™/CVI, Lookout™, HiQ™, and much more. The free multimedia CD also offers direct access to product and order information via the Internet. Call or visit the National Instruments Web site for your free CD! National Instruments; Tel: 800-433-3488 (U.S. and Canada); 512-794-0100; Fax: 512-683-9300; e-mail: info@ni.com; www.ni.com/info/showcase

National Instruments

For More Information Circle No. 613

PXI™— COMPACTPCI FOR MEASUREMENT AND AUTOMATION

PXI modular instrumentation empowers you to meet your measurement and automation challenges in the most effective way possible. By combining PC technology with CompactPCI modular industrial packaging, timing and triggering, and the industry's best software, National Instruments brings you the widest selection of PXI/CompactPCI solutions for test, measurement, data acquisition, and industrial automation. National Instruments; Tel: 800-894-0885 (U.S. and Canada); 512-794-0100; Fax: 512-683-9300; e-mail: info@ni.com; www.ni.com/info/pxi

National Instruments

For More Information Circle No. 614

VIBRATION ISOLATION & IMPACT ABSORPTION

New, full-color brochure describes the dynamic properties of Sorbothane, the unique vibration isolation and impact absorption material. New test data details the damping properties of Sorbothane compared to other elastomers. Sorbothane is a patented visco-elastic polymer. Includes information on Sorbothane's new line of advanced vibration isolation/shock absorption products, as well as applications engineering, manufacturing capabilities, and the many applications for Sorbothane. Sorbothane, Inc.; Tel: 330-678-9444; Fax: 330-678-1303; e-mail: webmaster@www.sorbothane.com; http://www.sorbothane.com

Sorbothane, Inc.

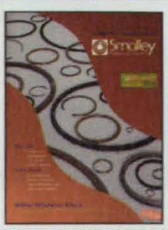
For More Information Circle No. 615

POROUS CERAMIC VACUUM CHUCK

PhotoMachining offers a porous ceramic vacuum chuck for use with thin films and other flat samples. Pore sizes under 25 microns assure uniform suction and holding power for even the smallest parts. PhotoMachining also provides contract laser-manufacturing services, and designs and builds custom laser-based manufacturing equipment. PhotoMachining, Inc., 4 Industrial Dr., Unit 40, Pelham, NH 03076; Tel: 603-882-9944; Fax: 603-886-8844; rschaeffer@photomachining.com; www.photomachining.com

PhotoMachining, Inc.

For More Information Circle No. 616



SPIRAL RETAINING RING CATALOG

Smalley Steel Ring Co. introduces the new '99 edition catalog, #RR-99. It offers more than 4000 stock Spiral Retaining Rings, available in both carbon or stainless steel, with diameters ranging from 3/8" to 84". Complete engineering data is included in this 56-page manual. Spirals have no ears to interfere. Spiral Retaining Rings install easily and can be removed with a screwdriver. Smalley engineers are available for free design help. Smalley Steel Ring Co., 385 Gilman Ave., Wheeling, IL, 60090; Tel: 847-537-7600; Fax: 847-537-7698; www.smalley.com

Smalley Steel Ring Co.

For More Information Circle No. 617

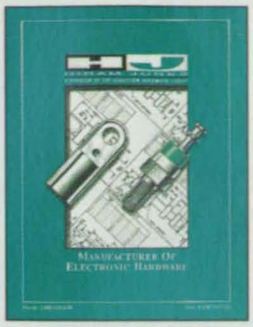
FREE! MOTION CONTROL CATALOG

YR 2000 catalog includes full specs on Galil's programmable motion controllers available in ISA, PCI, PC/104, VME, RS-232/422, USB and Ethernet formats. Configurable for steppers and serbos. Features program memory, uncommitted I/O and all modes of motion. Software tools for autotunning and interface to Visual Basic. Catalog includes 20-page technical reference about motion control systems. Visit www.galilmc.com. Marketing contact: Lisa Wade. Galil Motion Control, 203 Ravendale Drive, Mountain View, CA 94043; (650) 967-1700; (800) 377-6329; fax (650) 967-1751; www.galilmc.com

Galil Motion Control

For More Information Circle No. 618

LITERATURE & WEB SITE SPOTLIGHT



Hiram Jones Electronics, Inc./A Division of the Seastrom Hardware Group manufactures a complete line of standard miniature and subminiature terminals including: insulated test jacks, assembled standoffs and press-type terminals. All standard catalog items are available for immediate pricing and delivery. Call today for your free 27-page catalog: 800-634-2356.

Hiram Jones Electronics, Inc.

For More Information Circle No. 619

THE SOURCE FOR ELECTRONIC & MECHANICAL HARDWARE

Seastrom takes pride in offering one of the widest selections of standard electronic and assembly hardware available from stock. Seastrom's 66-A Catalog provides a complete source for over 45,000 products. For a free 550-page catalog, call 800-634-2356.

Seastrom Mfg Co. Inc.

For More Information Circle No. 620

FREE 2000 QUATECH PRODUCT CATALOG & CD

Quatech's 2000 catalog details our extensive line of quality communication, data acquisition, and signal conditioning products for USB, PCMCIA, PCI, and ISA. New for 2000 are the FreedomUSB Series of multi-port USB serial adapters and USB hubs. Available in print or as an interactive CD linked to our secure online ordering system, the catalog provides product overviews, photos, and complete technical specifications. Call 1-800-553-1170 for your free copy or visit *www.quatech.com.*

Quatech, Inc.

For More Information Circle No. 621

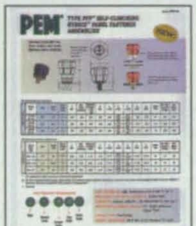
LIGHTED INTERFACE SWITCH CONTROLLER-XT

Literature from StacoSwitch details the Interface Controller-XT (IFC-XT) — a flexible, low-cost digital I/O controller designed to manage clusters of lighted pushbutton switches, LEDs, and incandescent lamps. Features include 32 input and 32 output channels, audible tone generation, adjustable output levels of all lamps individually, and RS-232 and RS-422 capability; simple software driver set; compact size; easy direct mount. StacoSwitch; Tel: 714-549-3041; Fax: 714-549-0930; e-mail: sales@stacoswitch.com; www.stacoswitch.com

StacoSwitch Co.

For More Information Circle No. 622

HYBRID™ PANEL FASTENERS (BULLETIN PFP)



These new Type PFP™ self-clinching HYBRID panel fasteners feature a steel retainer and screw with a black ABS cap. The "spring action" of the cap's plastic "fingers" allows the knob to be held in a retracted position until it is tightened down. A universal slot/Phillips drive is standard. Optional colors are available. Penn Engineering & Mfg. Corp.; Tel: 800-237-4736; Fax: 215-766-0143; www.pemnet.com

Penn Engineering & Mfg. Corp.

For More Information Circle No. 623

STORAGE ENCLOSURES

Kingston's storage enclosures are specifically designed to meet your long-term storage needs. Kingston offers an unparalleled variety of high-quality, mix-and-match enclosures that provide compatibility-tested housing for full- and half-height fixed or removable drives. All products are supported with an industry-leading warranty and superior customer service. Contact Kingston today to request a free 30-day evaluation or request information and literature online at www.kingston.com/storage/inforeq.asp. Enter pass code NTBS1 and receive a free gift with your literature packet. Tel: 714-438-1850; e-mail: Storage@kingston.com; www.kingston.com/storage.

Kingston

For More Information Circle No. 624

DEVICE DATA INTO WINDOWS APPLICATIONS

WinWedge instantly inputs serial (RS232-RS485) or TCP/IP data into any Windows application: Excel, Access, MMIs, etc. Collect data from and control gauges, micrometers, balances, meters, bar-code scanners, measuring instruments ... any device. Easily perform graphing and analysis of your instrument data in any program. TalTech, 2027 Wallace St., Philadelphia, PA 19130; Tel: 800-722-6004, 215-763-7900; Fax: 215-763-9711; www.taltech.com

TalTech

For More Information Circle No. 625

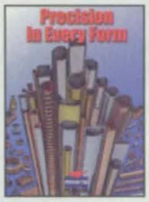
SMALL PARTS CATALOG NO. 20 QUALITY COMPONENTS, MATERIALS, AND TOOLS

This catalog is packed with products for engineering design, research and development, prototypes and modeling, and industrial assembly. Thousands of items are in stock, including miniature fasteners, specialty components, fluid and motion control devices, select materials, and precision tools. SMALL PARTS, INC., 13980 NW 58th Court, Miami Lakes, FL, 33014, Attn: Free Catalog - Dept. 200F; Tel: 800-220-4242; Fax: 800-423-9009; www.smallparts.com

Small Parts, Inc.

For More Information Circle No. 626 or visit www.nasatech.com/626

TUBING/PARTS FABRICATION

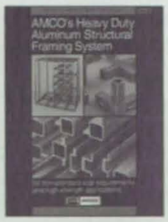


Precision Tube Co.'s .00025" tolerance with O.D.'s from .010" to 2.00" assures optimum tubing and tubular parts. These products are fabricated from aluminum, brass, copper, bronze, and 22 nonferrous alloys. They include straight-length and coiled tubing, waveguide tubing, and complex small parts for electronics, HVAC, recreation, medical equipment, defense, aerospace, and more. Application Engineering services are available. Precision Tube Co., a Mueller Industries Company; 287 Wissahickon Ave., North Wales, PA 19454; Tel: 215-699-5801; Fax: 215-699-0761; e-mail: prectube@precisiontube.com; www.precisiontube.com

Precision Tube Co.

For More Information Circle No. 627

ALUMINUM FRAMING SYSTEMS



AMCO offers a one-of-a-kind aluminum structural system to simplify the design of specialized and nonstandard enclosures. This system allows customers to build enclosures, racks, or stands from 8" to 20' in any 90-degree plane. Features include high-strength extruded tubing with 11 different integral flange configurations; 3 types of accessory-mounting channels; 7 joining and corner castings, and more. Request catalog 203. AMCO Engineering Co., Schiller Park, IL; Tel: 1-800-833-3156, 847-671-6670; Fax: 847-671-9469; www.amcoengineering.com

AMCO Engineering Co.

For More Information Circle No. 636

AIRSTROKE®, AIRMOUNT® ENGINEERING MANUAL & DESIGN GUIDE

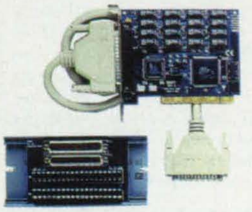
Firestone Industrial Products Company offers a revised version of its Engineering Manual and Design Guide for Airstroke® actuators and Airmount® isolators. The free manual provides updated guidelines and specs for the air springs, including height, force, and stroke data. Also included are examples of typical isolation and actuation problems that can be solved by using air springs. Firestone Industrial Products Co., 12650 Hamilton Crossing Blvd., Carmel, IN 46032; Tel: 800-888-0650; www.firestoneindustrial.com

Firestone Industrial Products Co.

For More Information Circle No. 628

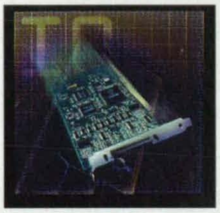
New on the MARKET

PCI Digital I/O Card



The REL-16.PCI 16-output digital I/O interface for the PCI bus from Sealevel Systems, Liberty, SC, features 16 reed-relay outputs that can be utilized for PC-based control and automation of equipment, including switches, satellite antenna control systems, video and audio studio automation, security control systems, and other industrial-automation systems. Other applications include integrating unattended status-monitoring equipment, and fall-back network switching circuits. The card ships with the Seal/O suite of Windows 95/98/NT/2000 drivers. **Circle No. 735**

Data Acquisition Board

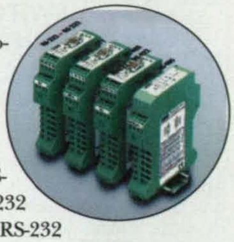


The Model KPCI-3140 counter/timer/digital I/O board from Keithley Instruments, Cleveland, OH, combines timing, frequency and event counting, and digital I/O with a suite of free software. Features include eight 16-bit counter timers, each with an internal clock, external clock and gate inputs, and clock output; four internally driven, 24-bit interval timers able to interrupt the computer's CPU on time-out; and 32 channels of programmable digital I/O with high current drive and CPU interrupt. Software includes programs, drivers, and utilities supporting industry-standard programming languages and DAQ packages. **Circle No. 736**

Digital Input Card

The CompuScope 3200 from Gage Applied Sciences, South Burlington, VT, is a single-slot, 32-bit digital input card for the PCI bus. It is capable of simultaneous sampling at clock rates up to 100 MHz. Inputs can be factory-set to be either differential or single-ended. The card can be configured, in software, to be 8, 16, or 32 bits wide, allowing maximum use of storage memory for 8- or 16-bit inputs. It also can be used to stream data across the PCI bus into host memory, making it possible to capture gigabytes of gapless digital data. **Circle No. 738**

Isolators and Converters



Phoenix Contact, Harrisburg, PA, has introduced the PSM-ME series of DIN-rail mountable serial-data isolators and converters that are 0.89" wide. They provide conversion and isolation for serial data interface standards including TTY digital current loop and RS-232, -422, and -485. The user-selectable RS-232 to 422/485 converter allows the extension of RS-232 signals beyond its specified 50-foot limitation. The units also feature 2kV, three-way isolation, surge protection, and filtered shield connection. **Circle No. 739**

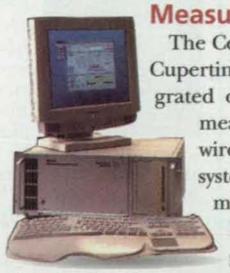
Flange-Mount Plastic Nut

The XCF-1800 flange-mount plastic nut from Ball Screws and Actuators, San Jose, CA, is designed for use with 3/16" and 1/4" leadscrews. It is suitable for 5-pound load-capacity applications such as small consumer-electronic devices, disk-drive mechanisms, medical tools, and computer peripherals. The nut features ActiveCAM technology to achieve zero backlash and minimal drag torque. A thread-mount version also is available. **Circle No. 740**

Waveform Generator

The Agilent 33250A from Agilent Technologies, Colorado Springs, CO, is an 80-MHz, function/arbitrary waveform generator designed for use by engineers on the benchtop or in test systems. It can generate standard waveforms from sine and square to ramp and sawtooth for circuit testing, design verification, and waveform simulation. The generator's direct digital synthesis techniques allow users to create accurate output on all waveforms down to 1μHz frequency resolution. Features include high-resolution color graphical display, and GPIB and RS-232 interfaces with full programmability using SCPI programming commands. **Circle No. 741**

Measurement Test Set



The Celerity Systems division of L-3 Communications, Cupertino, CA, has introduced the CS29010 fully integrated distortion measurement test set for test and measurement of cellular, PCS, satellite, LMDS, wireless data, and all communications or data-link systems operating in complex multi-channel and multi-signal environments. Features include 45 MHz at 12 bits bandwidth, arbitrary waveform generation, radio frequency up/down conversion, and wideband recording capability with 4 GB RAM through a 600-MHz Pentium III processor with a Windows NT™ operating system. The system includes LabVIEW™-configured measurement and control software. **Circle No. 742**

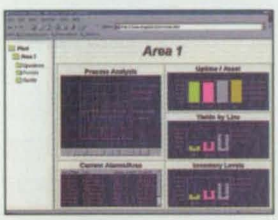
New on DISK

Web-Enabled Design Automation

I-DEAS® 8 design automation software from SDRC, Milford, OH, features new collaboration solutions that allow users to leverage the Internet across the entire product life cycle. It incorporates 3D annotation and organizational tools, allowing users to document and manufacture a 3D digital prototype, eliminating 2D drawing documentation. Other enhancements include a drafting application, free-form surface modeling, feature-based modeling, large-assembly management, and new capabilities for reverse engineering, mold design, and simulation. I-DEAS Web Access enables secure access to I-DEAS product structure and geometry through a standard web browser. **Circle No. 720**

Data Visualization

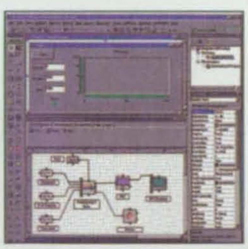
Visual Numerics, Boulder, CO, has introduced Version 2.0 of INVIZION, a customizable time-series analysis application written in the company's PV-WAVE development product. Features include a Windows-like menu interface for easier navigation; improved methods for accessing customer data files; and an interactive zoom-and-pan function, which lets users manipulate specific data points for more detailed analysis. Available for UNIX-based workstations and for PCs running Windows 95/98/NT, the software enables time-series analysis of data and the ability to graphically display results via custom plot page layouts. **Circle No. 721**



Plant Information Portal

Version 8.0 of Illuminator™ Plant Information Portal™ from Lighthammer Software Development Corp., Exton, PA, enables visualization of information from any plant data source via any browser or Internet-enabled device. It includes several features designed to allow wider application of the technology across many markets. New tools enable development of advanced web pages by users with no background in HTML, Java, or VB Scripting. The software allows any company to begin an e-business strategy, connecting a broad set of data sources to any user's thin-client browser. **Circle No. 722**

Graphical Programming



SoftWIRE™ from ComputerBoards, Middleboro, MA, combines graphical programming with the ability to write code in an industry-standard language. Functions are selected from a simple menu; the objects are placed onscreen as desired and then connected with a few drag-and-drop wires. The program is then ready to run. All SoftWIRE control blocks are fully COM/ActiveX compatible and can be interfaced to Visual Basic programs. Applications include test and measurement, analysis, automation, and database management. **Circle No. 723**

Real-Time System Development

ARTiSAN Software Tools, Portland, OR, has launched version 3.1 of its Real-time Studio® modeling suite that enables design teams to capture software and system design, automate the captured designs, and integrate them into a complete process, without disrupting existing development environments. The program also can import various model elements from Rational Rose. Other enhancements include an improved Java code generator and increased enterprise scalability. An updated synchronizer allows changes in a model to be incorporated faster. A strengthened external class mechanism simplifies re-use in legacy systems. **Circle No. 724**

New LITERATURE

Non-Contact Measurement Systems

A brochure from Optimet, Danvers, MA, describes non-contact dimensional measuring systems that use conoscopic holography to create precise, dimensional digital images of virtually any surface at high speed. Products include the Conoprobe 1000, a general-purpose non-contact measuring probe; the Conoscan 2000, a non-contact profilometer; and the Conoscan 3000, which provides 3D measurement capability using high-precision X and Y stages. **Circle No. 700**

Digital Transducer Indicators

Sensotec, Columbus, OH, offers a brochure on the SC Series of self-calibrating, digital transducer indicators. The SIG CAL capability enables the instrument to automatically calibrate itself to any transducer equipped with an internal signature chip. The indicators will accommodate up to 14 plug-in signal conditioner cards for use with all strain gauge sensors. **Circle No. 701**

Touch Probes

An interactive CD from Heidenhain Corp., Schaumburg, IL, gives a multimedia demonstration of the company's Touch Probe line. Topics include principles of operation, application examples, and electrical and mechanical specifications. Products include cabled and infrared spindle probes, as well as tool touch probes. **Circle No. 702**

Sensors and PLCs

Keyence Corp. of America, Woodcliff Lake, NJ, has released a brochure on expandable safety light curtains, two-color digital display pressure sensors, and RGB digital fiber-optic sensors. Products include the FS-V10 fiber-optic sensor with a dual monitoring system, the ultra-compact BL-600 series laser bar-code readers, and the Visual KV series compact programmable logic controller. **Circle No. 703**

Fluid-Sealing Products

The Sealant Technologies Group of W.L. Gore & Associates, Elkton, MD, has released a brochure describing its fluid-sealing products made from GORE-TEX® expanded PTFE or other proprietary forms of PTFE. Products include sheet gasketing, form-in-place gaskets, gasket tape, pump packings, valve stem packing, and pump diaphragms. **Circle No. 704**

Specialty Alloys

Carpenter Technology Corp., Reading, PA, offers a 40-page color brochure describing its high-performance specialty alloys and metalworking services. Products include more than 450 types of stainless steels, high-temperature (iron-nickel-cobalt-base) alloys, electronic alloys, tool steels, and other special-purpose metals. **Circle No. 705**

Advertisers Index

Advertisers listed in bold-face type also have banner ads on the *NASA Tech Briefs* web site this month. Visit **www.nasatech.com**

Company	Web Site	Circle Number	Page
ACR Systems Inc.	www.acrsystems.com	425	56
Aero Tec Laboratories	www.atlinc.com	489	63
Agilent Technologies	**www. agilent.com/find/power_supply**	**529**	**39**
Algor, Inc.	**www.feaincad.com, www.algor.com, www.PipePak.com, www.algor.com/webcast, www.eTechLearning.com**	**599, 510, 519, 610, 611, 612**	**7, 53, 61, 66**
AMCO Engineering Co.	www.amcoengineering.com	636	67
Ansoft	www.ansoft.com	460	41
Ansys, Inc.	www.ansys.com	534	33
Astro-Med, Inc.	**www.astro-med.com/ev16**	**518**	**2**
Autodesk	www.autodesk.com/rocket	516	21
W.M. Berg,Inc.	www.wmberg.com	606	9b
Boxlight Corporation	www.boxlight.com	491	63
Carpenter	www.cartech.com/aero	512	4-5
CFD Research Corporation	www.cfdrc.com	544	23
CollabWare	www.collabware.com	539	13
Comsol, Inc.	**www.comsol.com**	**429**	**58**
Cosmos/™	www.cosmosm.com	523	51
Deneba Systems Inc.	www.deneba.com/ntb	569	37
The Deschner Corporation	www.deschner.com	426	68
Dewetron, Inc.	**www.dewamerica.com**	**533**	**27**
Digi-Key Corporation	www.digikey.com	535	3
Electrocube	www.electrocube.com	480	4a
Encoder Products Co.	www.encoderproducts.com	604	8b
Engineering Design Team, Inc.	**www.edt.com**	**416**	**34**
Engineering-e.com	**www.engineering-e.com/e**	**531**	**17**
Firestone Industrial Products Co.	www.firestoneindustrial.com	628	67
Foresight Imaging	www.foresightimaging.com	548	11
Gage Applied Sciences Inc.	www.gage-applied.com/ad/nasa600.htm	412	16
Galil Motion Control	www.galilmc.com	618	66
Gordon Products, Incorporated	www.gordonproducts.com/analognt.htm	473, 474	9a
GSA Federal Supply Service	http://pub.fss.gsa.gov/services/engineering	414	8
Hardigg Cases	www.hardigg.com	420	24
Helical Products Co.	www.Heli-Cal.com	605	8b
Hiram Jones Electronics, Inc.		619	67
Integrated Engineering Software	www.integrated.ca	423	54
IOtech, Inc.	www.iotech.com	401-403	24A-B
Keithley Instruments, Inc.	**www.keithley.com**	**506, 608**	**45, 66**
Kingston	**www.kingston.com/storage.**	**624**	**67**
LPKF Laser & Electronics	www.lpkfcadcam.com	470	1a
Master Bond Inc.	**www.masterbond.com**	**427, 484**	**69, 8a**
The MathWorks, Inc.	**www.mathworks.com/nasb**	**571**	**19**
Melles Griot	**www.mellesgriot.com/mg167.htm**	**600**	**1b**
Metrum-Datatape	**www.metrum-datatape. com**	**408**	**48**
Microway	www.microway.com	568	55
Minalex		607	66
Minco Products, Inc.	www.minco.com	428	69
Mouser Electronics	www.mouser.com	486	8a
MSC Software	**www.mscsoftware.com/offers**	**525**	**COV III**
National Instruments Corporation	**www.ni.com/info/lvrt, www.ni.com/info/16bitdaq, www.ni.com/info/motion, www.ni.com/info/showcase, www.ni.com/info/pxi**	**500, 421, 602, 613, 614**	**COV II, 47, 5b, 66**
NOOK Industries	www.nookindustries.com	601	3b
Numerical Algorithms Group, Inc.	www.nag.com	417	35
NuSil Silicone Technology	www.nusil.com	413	22
Omega Engineering, Inc.	www.omega. com	503, 504, 609	1, 66
Penn Engineering & Manufacturing Corporation	**www.pemnet.com**	**468, 623**	**7a, 67**
PhotoMachining, Inc.	www.photomachining.com	616	66
Pittman	www.pittmannet.com	603	7b
Precision Tube Co.	www.precisiontube.com	627	67
Presray Corporation	www.presray.com	415	28
Quatech, Inc.	www.quatech.com	621	67
Research Systems, Inc.	www.researchsystems.com/trends	508	COV IV
RGB Spectrum	**www.rgb.com**	**410**	**10**
Rifocs Corporation	www.rifocs.com	418	46
ScienceWise.com	www.sciencewise.com	573	15
Seastrom Mfg Co. Inc.		620	67
Silicon Graphics, Inc.	www.sgifederal.com	560	43
Small Parts, Inc.	www.smallparts.com	626	67
Smalley Steel Ring Co.	www.smalley.com	617	66
Solid Edge, Unigraphics Solutions	**www.solid-edge.com**	**541**	**57**
Sony Precision Technology America	www.sonypt.com	527	3a
Sorbothane, Inc.	www.sorbothane.com	615	66
Sorensen	www.sorensen.com	466	COV IIa
StacoSwitch Co.	www.stacoswitch.com	622	67
Stanford Research Systems	www.thinkSRS.com	513	59
StereoGraphics Corporation	www.stereographics.com/democd/	419	46
StorCase Technology, A Kingston Technology Company	**www.storcase.com**	**532**	**9**
Superbolt, Inc.	www.superbolt.com	424	56
Synrad, Inc.	www.synrad.com	411	14
3Dshare.com by PlanetCAD, a division of Spatial	**www.3Dshare.com, www.PlanetCAD.com**	**540**	**29**
TalTech	www.taltech.com	625	67
Test Mart	**www.testmart.com**	**555**	**49**
TSI Incorporated, Flowmeter Division	http://flowmeters.tsi.com	422	50
Xerox Engineering Systems	www.XES.com	442	70

NASA Tech Briefs, ISSN 0145-319X, USPS 750-070, copyright ©2000 in U.S. is published monthly by Associated Business Publications Co., Ltd., 317 Madison Ave., New York, NY 10017-5391. The copyright information does not include the (U.S. rights to) individual tech briefs that are supplied by NASA. Editorial, sales, production, and circulation offices at 317 Madison Ave., New York, NY 10017-5391. Subscription for non-qualified subscribers in the U.S., Panama Canal Zone, and Puerto Rico, $75.00 for 1 year; $135 for 2 years. Single copies $5.00. Foreign subscriptions one-year U.S. Funds $195.00.

Remit by check, draft, postal, express orders or VISA, MasterCard, and American Express. Other remittances at sender's risk. Address all communications for subscriptions or circulation to *NASA Tech Briefs*, 317 Madison Ave., New York, NY 10017-5391. Periodicals postage paid at New York, NY and additional mailing offices.

POSTMASTER: Send address changes to *NASA Tech Briefs*, PO Box 10523, Riverton, NJ 08076-9023.

Ride-along enclosed in all versions

This Month in

Rapid Product Development ....online

Tools & Techniques To Create Better Products Faster

The web publication for *NASA Tech Briefs* readers

NASA Tech Briefs' totally digital publication, Rapid Product Development Online (www.rapidproducts.net), helps engineers develop better products faster by giving them immediate, 24-hour access to the latest information on CAD, FEA, modeling, reverse engineering, and rapid prototyping tools and techniques.

RPD Online includes feature stories, industry and product news, product reviews, show coverage, demos, links, and a keyword-searchable supplier guide.

This month's RPD Online includes:

- **Fused Deposition Modeling in Microgravity** — Researchers are evaluating Fused Deposition Modeling (FDM) and similar techniques for meeting the challenges of space-based manufacturing aboard long-duration, manned missions.
- **Toymaker Cuts Design Time in Half** — Feber International, a manufacturer of injection-molded plastic toys, has developed a dynamic, flexible system based on numerical control (NC) and CAD/CAM technologies.
- **Translating CAD Models Overnight** — General Pattern, a supplier of rapid prototyping services, turned to an automated online service to complete an urgent project in record time.
- **New Products** — This month's featured products include a computer-controlled machine for desktop manufacturing, a new line of resins for stereolithography, and a mold design and manufacturing software package.

Sponsors:

SOLID EDGE

Solid Edge is Unigraphics Solutions' mid-range CAD software package.

Spatial

Be sure to visit www.rapidproducts.net for the latest information on the rapid product development industry. For advertising and sponsorship information, contact Joe Pramberger at joe@abptuf.org; Tel: 212-490-3999.

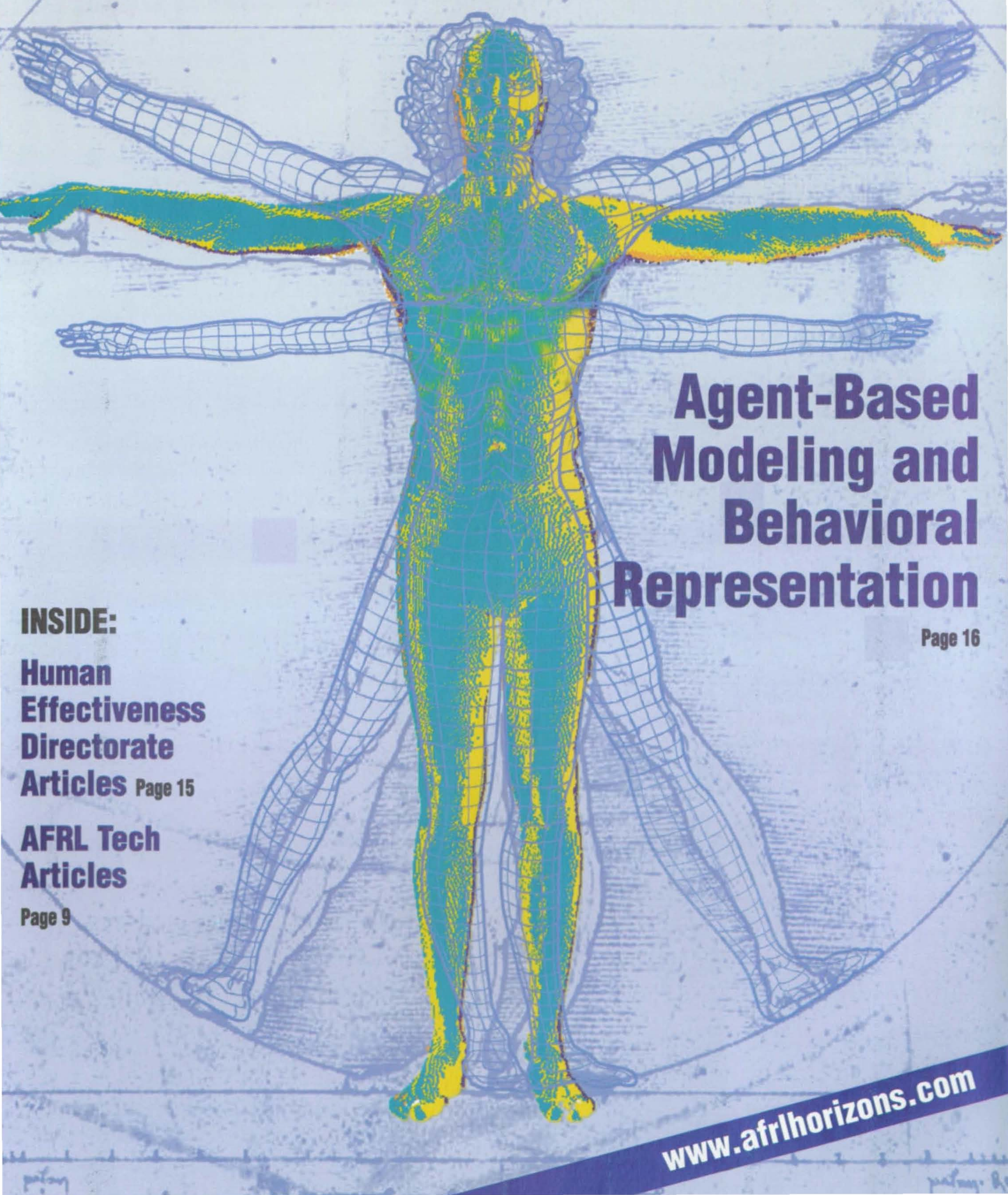
www.rapidproducts.net

AFRL

Volume 1 • Number 2 • June 2000

TECHNOLOGY HORIZONS™

SELECTED SCIENCE AND TECHNOLOGY ARTICLES



Agent-Based Modeling and Behavioral Representation

Page 16

INSIDE:

www.afrlhorizons.com